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Limes, Cements, Mortars, and Concretes. Collected from the observations and experiments of Generals Gilmore and Totten, U. S. A., and MM. Vicat, Chatoney, Rivot, and Dupont. By CHAS. H. HASWELL, Civil and Marine Engineer, N. Y.

No. 1.

The calcination of marble or any pure limestone produces *lime*, (*quicklime.*)

Lime, from its great affinity for moisture and carbonic acid, requires to be preserved from these deteriorating agents by being packed in close vessels.

Limestones.—The pure limestones burn to a white lime and give the richest limes.

The finest calcareous minerals are the rhombohedral prisms of calcareous spar, the transparent double-reflecting Iceland spar, and white or statuary marble.

In order that lime when brought to the condition of a paste for use as a binding medium shall afterwards harden to solidity, it is necessary that other substances exist in a state of intermixture with it; and these substances are found to be silica, alumina, magnesia, iron, manganese, &c.

The striking and characteristic property of hardening under water, or when excluded from the air, conferred upon a paste of lime by these

foreign substances, when their aggregate amount exceeds one-tenth of the whole, furnishes the basis for a general arrangement of all natural or artificial products suitable for mortars, into five distinct classes, as follows:

1st. The common or fat limes.

2d. The poor or meagre limes.

3d. The hydraulic limes.

4th. The hydraulic cements.

5th. The natural puzzuolanas, including puzzuolana, properly so called, trass or terras, the arènes, ochreous earths, schists, grauwacké, and basaltic sands, and a variety of similar substances.

Rich limes are dissolved fully in water frequently renewed, and they remain a long time without hardening; they also increase greatly in volume, from 2 to 3·5 times their original bulks, and will not harden without the action of the air. They are rendered *hydraulic* by the admixture of *puzzuolana* or *trass*.

Rich, fat, or *common limes* usually contain less than 10 per cent. of impurities.

Hydraulic limestones are those which contain iron and clay, so as to enable them to produce cements which become solid when under water.

The pastes of fat limes shrink, in hardening, to such a degree that they cannot be used as mortar without a large dose of sand.

Poor limes have all the defects of rich limes, and increase but slighty in bulk.

The poorer limes are invariably the basis of the most rapidly setting and most durable cements and mortars, and they are also the only limes which have the property, when in combination with silica, &c., of indurating under water, and are, therefore, applicable for the admixture of hydraulic cements or mortars.

They generally contain silica (in the shape of sands), alumina, magnesia, oxide of iron, oxide of manganese, and, in most cases, traces of the alkalies in relative proportions which vary very considerably in different localities. Their aggregate amount is seldom less than ·10 or greater than ·25, although, in some varieties, it reaches as high as ·35, and even, though rarely, ·39 of the whole. In slaking, they proceed sluggishly as compared with the rich limes, and seldom produce a homogeneous and impalpable powder. They exhibit a more moderate elevation of temperature in slaking, and are accompanied by a much smaller increase of volume than rich limes. Like the latter, they dissolve in water frequently renewed, though more sparingly, owing to the presence of a larger amount of impurities, and, like them, they will not harden if placed in the state of paste under water or in wet soil, or if excluded from contact with the atmosphere, or carbonic acid gas. They should be employed for mortar only when it is impossible to procure common or hydraulic lime, or cement, in which case it is recommended, if practicable, to reduce them to powder by grinding.

Lime absorbs in slaking a mean of 2·5 times its volume and 2·25 times its weight of water.

Hydraulic limes are those which readily harden under water. The most valuable or "eminently hydraulic" *set* from the second to the fourth day after immersion; at the end of a month they become hard and insoluble, and at the end of six months they are capable of being worked like the hard natural limestones.

They absorb less water than the pure limes, and only increase in bulk from 1·75 to 2·5 times their original volume.

The inferior grades, or "moderately hydraulic," require a longer period, say from fifteen to twenty days immersion, and continue to harden for a period of six months.

The property of hardening under water or when excluded from air, conferred upon a paste of lime, is effected by the presence of foreign substances as silicum, alumina, iron, &c., when their aggregate presence amounts to one-tenth of the whole.

The resistance of hydraulic limes increase if the sand is mixed in the proportion of 50 to 180 *per centum* of the part in volume; from thence it decreases.

As a general rule these limes undergo, in slaking, an increase of volume inversely proportional to their hydraulicity and quickness.

Slaked lime is a hydrate of lime.

M. Vicat declares that lime is rendered hydraulic by the admixture of a proportion of from 33 to 40 *per centum* of clay and silica, and that a lime is obtained which does not slake, and which quickly sets under water.

Artificial hydraulic limes do not attain, even under favorable circumstances, the same degree of hardness and power of resistance to compression as the natural limes of the same class.

The close-grained and densest limestones furnish the best limes.

Hydraulic limes lose or depreciate in value by exposure to the air.

Arènes is a species of ochreous sand claimed to be of fossil origin. It is found in France. On account of the large proportion of clay it contains, sometimes as great as seven-tenths, it can be made into a paste with water without any addition of lime, and hence it is sometimes used in that state for walls constructed *en pisé*, as well as for mortar.

Mixed with rich lime, it gives excellent mortar, which attains great hardness under water and possesses great hydraulic energy.

Puzzuolana is of volcanic origin. It comprises trass or terras, the arènes, some of the ochreous earths, and the sand of certain grauwackés, pramuntes, granites, schists, and basalts; their principal elements are silica and alumina, the former preponderating. None contain more than ten per cent. of lime.

When finely pulverized, without previous calcination and combined with the paste of fat lime, in proportions suitable to supply its deficiency in that element, it possesses hydraulic energy to a valuable degree. It is used in combination with rich lime, and it may be made by slightly calcining clay and driving off the water of combination at a temperature of 1200°.

Trass or terras is a blue-black trap, is also of volcanic origin.

It is obtained from pits of extinct volcanoes, and has nearly all the distinguishing elements of puzzuolana, resembling it in composition and in the requirements of its manipulation, requiring to be pulverized and combined with rich lime, to render it fit for use and to develop any of its hydraulic properties.

For an analysis of them, see Busnell on limes, cements, mortars, &c.

Brick or Tile dust combined with rich lime possesses hydraulic energy.

General Gilmore* designates the varieties of hydraulic limes as follows: If, after being slaked, they harden under water in periods varying from fifteen to twenty days after immersion, *slightly hydraulic*; if from six to eight days, *hydraulic*; if from one to four days, *eminently hydraulic.*

The aggregate of silica, alumina, magnesia, oxide of iron, &c., contained in these limes seldom exceeds ·35 of the whole. The proportion in the first class varying from ·10 to ·20 of the whole, in the second class from ·17 to ·24, and in the latter class from ·20 to ·35.

Pulverized silica burned with rich lime produces hydraulic lime of excellent quality. In experiments by MM. Chatoney and Rivot, this lime hardened under water in from three to four days, and acquired in twenty-two months a hardness superior to Portland cement.

The weight of the powdered lime never exceeded four times, and never less than one-half that of the powdered silica.

Hydraulic limes in their composition, and in their value for application to the purposes of construction, and in their geological position, occupy an intermediate place between the *common or fat* limes and the hydraulic cements. They are found in the United States in numerous and extensive deposits.

Hydraulic limes are injured by air slaking, in a ratio varying directly with their hydraulicity, and they deteriorate by age.

For foundations in a damp soil or exposure, hydraulic limes must be exclusively employed.

Cements.

Hydraulic cements contain a larger proportion of silica, alumina, magnesia, &c., than any of the preceding varieties of lime; they do not slake after calcination, and they are superior to the very best of hydraulic limes, as some of them set under water at a moderate temperature (65°) in from three to four minutes; others require as many hours. They do not shrink in hardening and make an excellent mortar without any admixture of sand.

Roman Cement is made from a lime of a peculiar character found in England and France, derived from argillo-calcareous kidney-shaped stones, termed "Septaria," and when mixed thick it solidifies in a few minutes either in air or water; hence, for some purposes, it is of great utility and for others its use is impracticable.

*See his Treatises on Limes, Hydraulic Cements, and Mortars, of Papers on Practical Engineering, Engineers' Department, U. S. A.

The manufactured article takes its name from the locality of the store, as "Boulogne" or "Sheppy."

Rosendale cement, from the township of Rosendale, N. Y., is derived from the water limestone of the Helderburg group, Ulster county, New York.

Portland cement is made in England and France from an argillo-calcareous deposit, which is burned and ground up for cement in its natural state, without the addition of lime. It requires less water than the Roman cement. It sets slowly, and can be remixed with additional water after an interval of twelve or even twenty-four hours from its first mixture.

The property of setting slow may be an obstacle to the use of some designations of this cement, as the Boulogne, when required for localities having to contend against immediate causes of destruction, as in sea constructions having to be executed under water and between tides. On the other hand, a quick setting cement is always difficult of use; it requires special workmen and an active supervision. A slow setting cement, however, like the natural Portland, possesses the advantage of being managed by ordinary workmen, and it can be remixed with additional water after twelve or even twenty-four hours.

Artificial cement is made by a combination of slaked lime with unburnt clay in suitable proportions, burning the mixture in a kiln or furnace and then grinding it, or by substituting for the lime a carbonate of a lime that can be pulverized without burning, or by using artificial puzzuolana, or by adding silica in a soluble form to a paste of common lime.

Artificial puzzuolana is made by subjecting clay to a slight calcination.—(*Pambour.*)

Salt water has a tendency to decompose cements of all kinds.

Mortars.

Lime or cement paste is the cementing substance in mortar, and its proportion should be determined by the rule, that *the volume of the cementing substance should be somewhat in excess of the volume of voids or spaces in the sand or coarse material to be united.* The excess being added to meet imperfect manipulation of the mass.

Hydraulic Mortar.—If re-pulverized and formed into a paste after having once *set*, immediately loses a great portion of its hydraulicity and descends to the level of the moderate hydraulic limes. A great destruction of the hydraulic principle therefore results from any disturbance of the molecular arrangement of the mortar, after crystalization has commenced. This is what occurs with the *intermediate* limes, which take initial *set* promptly and firmly, but which are subsequently thrown down by the slaking of the impure caustic lime which they contain.

All mortars are much improved by being worked or manipulated, and as rich limes gain somewhat by exposure to the air, it is advisable to work mortar in large quantities, and then render it fit for use by a second manipulation.

*Analyses of Hydraulic Limes, Cements, Trass, and Puzzuolana.**

No.	Specific Gravity.	Carbonic Acid.	Potash, Soda.	Silica, Alumina, Iron.	Lime.	Carbonate of Lime.	Magnesia and Carbonate.	Acids, Chlorides, Phosphates, &c.	Where from.
1	2·652		·62 ·88	25·20 6·16 2·02		58·84	10·38	·48	Utica, Illinois,
2	2·678		·40 12·10	19·66 3·14 3·86		40·54	17·98	·72	Sandusky, Ohio.
3	2·680		1·54 4·64	24·74 16·74 6·30		41·80	4·10	2·22	Cumberland, Md.
4	2·753			17·84 4·60 1·70		58·25	11·16	·74 3·26	Shepherdstown, Va.
5	2·844			18·52 2·18 1·86		43·30	26·04	1·96 4·24	High Falls, Ulster co., N.Y.
6	2·735			29·34 5·74 1·76		33·54	20·80	1·02 5·80	Do. do. do.
7	2·822			19·64 7·52 2·38		30·72	35·10	·64 4·10	Do. do. do.
8	2·761			18·46 4·22 2·32		37·50	35·62	·20 1·68	Do. do. do.
9	2·786			27·70 2·34 1·26		46·00	17·76	·26 4·02	Do. do. do.
10		31·00		18·00 5·25	30·20		·20		Sheppy, Eng., cement stone
11		29·00		17·75 6·00	35·00		·50		Nos. 1 and 2.
12		29·77		12·00 8·80	34·08		1·52		Southend, Eng. do.
13		31·00		24·00 1·31	30·50		1·04		Yorkshire, do. do.
14		22·75		9·375 17·75	29·25			7·50	Harwich, do. do.
15			7·0 1·0	57·0 5·0	2·6		1·0		Trass.
16			1·4 4·0	44·5 12·0	8·8		4·7		Puzzuolana.

Nos. 1 to 9 were analyzed by Prof. E. C. Boynton, Miss., and Nos. 10 to 16 by Berthier.

White lime will take a larger proportion of sand than brown lime.

The use of salt water in the composition of mortar injures the adhesion of it.

Mortar.—When a small quantity of water is mixed with slaked lime, a stiff paste is made, which, upon becoming dry or hard, has but very little tenacity, but, by being mixed with sand or like substances, it acquires the properties of a cement or mortar.

The proportion of *sand* that can be incorporated with mortar depends partly upon the degree of fineness of the sand itself, and partly upon the character of the lime. For the rich limes, the resistance is increased if the sand be in proportions varying from 50 to 240 *per centum* of the paste in volume; beyond this proportion, the resistance decreases.

* From Practical Treatises on Limes, Cements, and Mortars. By Gen. Gilmore, U. S. A.

Stone mortar.—325 lbs. cement, 120 lbs. lime, and 14·67 cubic feet of sand.

Brick mortar.—325 lbs. cement, 120 lbs. lime, and 12 cubic feet of sand.

Brown mortar.—Lime one part, sand two, and a small quantity of hair.

Lime and sand, and cement and sand, lessen about one-third in volume when mixed together.

(To be continued.)

The Catchment Basins of Rivers.

From the Lond. Civ. Eng. and Arch. Journal, February, 1865.

When Bramah about thirty-five years ago invented the water-closet, he little dreamt of the great sanitary and agricultural revolution he was inaugurating. We all know upon what trivial events momentous changes sometimes depend; but possibly in the whole history of our material progress no such example of this trite saying can be found than is afforded by the introduction of this useful appliance. Before its introduction the house drains were in no manner connected with the public sewers; the sewage flowed into cesspools which riddled our basements and perpetually gave forth deadly gases, which filled our houses, and killed us with fevers, while the main sewers only took off the surface drainage. They were simply the conductors of the water-shed of towns, and any attempt to turn the house drains into them was resisted by the Commissioners of Sewers. The rainfall through them found its way to the river, and the sewage to the land, which was removed at stated times by a service of nightmen, as it is at present in Paris and other large Continental cities, after doing all the mischief it could to the household, and after losing as much as possible of its own virtue for the purposes of the soil. When the hydraulic appliance of Bramah came slowly into operation, the cesspools could no longer hold the largely diluted sewage, and the evil became so great that the custom arose of flushing the house drains into the main sewers. This was clearly contrary to law, but it was winked at by the authorities; it was a great public necessity, in fact, which put all old arrangements aside, and slowly the whole sewage of the metropolis was conducted into the Thames. Those who remember the river thirty years ago can remember a comparatively pure stream, up which salmon used to work to their spawning grounds. Shortly, however, its color began to change from year to year, and at last it became so foul that, in 1859, white paper thrown into the stream was immediately blotted out by the dirty water, and the committee rooms of the Houses of Parliament became unbearable in consequence of the stench it gave forth.

Chief Justice Hale laid it down as law, that "every man was to keep his own dirt at home;" we did this, and probably should have gone on doing so until this day, had it not been for Bramah; he washed it up before our very eyes and noses in the river, and, more disgusting

still, he made us drink of it; and forthwith we commenced mighty works to take it down to the ocean. But other towns higher up the valley of the Thames having acquired powers under the newly constituted local Boards of Health, took example by the Metropolis, and transferred their cesspools into the stream, and thus commenced again the poisonous process we have taken so much trouble to abolish. Every day sewage is flowing down into our drinking water from the 800,000 persons located in the valley of the Thames above London. The gross absurdity of thus going to the expense of millions to get rid of our own sewage, that we may have the pleasure of drinking that of the fifty-three towns and villages of the upper Thames, must have struck every one. It is quite certain that the maxim—"every one for himself"—must, in its narrower interpretation, give way to some scheme for dealing with the difficulties thrown upon us by the independent action of local boards having jurisdiction over restricted areas only. The Thames valley, containing perhaps the most important elements of the problem to be solved, has attracted the greatest amount of attention.

Dr. Ackland, of Oxford, has for some time advocated the necessity of appointing some authority to control the catchment basins of rivers, and in conjunction with other gentlemen presented a memorial to Sir George Grey, two years since, with respect to the particular catchment basin of the Thames. The evidence he gives in the report before us of the condition of the river near Oxford is certainly disgusting He states that in one place the deposits of sewage have diminished the depth of the river by 6 feet, a "disengagement of gas takes place at the bottom of the water, and large masses of black sewage which have been deposited are thrown up to the surface," masses of human ordure totally unchanged are seen floating down the river for several miles. Every year the other large towns on the Thames—Abingdon, Wallingford, Reading, Windsor, Eton, Walton-on-Thames, Richmond, Brentford, &c., are obtaining powers to drain into the Thames. Each town thinks only of getting rid of its own refuse, quite regardless of the nuisance it is creating for the other towns lower down the stream. It is quite clear that no genuine system of fluvial purification can be carried out as long as mere local interests are allowed to be consulted.

Mr. Rawlinson, the principal inspector in the Local Government Act Office, who has inspected the rivers of Lancashire and parts of Yorkshire, says, (3993): "They are fouled almost from source of estuary." The rivers Irwell, Medlock, Irk, and the Bridgewater Canal, are more offensive from sewage than the Thames. The Medlock at Manchester is covered with a black scum so thick, that birds are able to walk over it. The rivers and streams in Lancashire and Yorkshire are fearfully abused. There are river beds in those counties that are raised 10 or 15 feet by sewage, ashes, and other refuse. "There are," says Mr. Rawlinson, "bridges under which a dog can scarcely creep, and I have had evidence from inhabitants that they have driven loaded carts under these same bridges." In the neighborhood of Birmingham the streams have been silted up many feet in the

same manner. The want of some central authority to deal with the watersheds of districts is illustrated by the case of Salford. The inhabitants of this town wished to carry their sewage by tunnel 3 or 4 miles from Manchester at an expense of £80,000, but were prevented from doing so by the refusal of other towns to co-operate. "Of what use is it," they say, "to expend large sums, when Manchester and all the other towns above will continue to foul the river?" The river at Birmingham contains in dry weather as much sewage as water. Birmingham once boasted of being one of the healthiest towns in England, but this distinction it has long lost, as its mortality is now much higher than that of the Metropolis, and it always suffers from a type of fever. The river Aire, which passes through Leeds and Bradford, is as foul as the Medlock. Passengers crossing the canal in trains are obliged to shut the windows, in consequence of foul air (4115). The Clyde at Glasgow is worse even than the Thames. We might, perhaps, expect to find filth in the rivers of manufacturing towns, but it is observable that places famed of old for hygienic advantages are now being poisoned by the practice of throwing the sewage into the river. The case of Bath is particularly strong. The river Avon, near that city, is nearly a stagnant stream, and is quite poisoned from this cause, and so great is the deposit of sewage in it, that the navigation is impeded. It is not quite so bad at Bristol, as a portion of the sewage of the town is diverted into the tidal river, but the floating-harbor which runs through the old town is quite pestiferous. The perverse arrangements which obtain in many of our watering-places are very observable. In many cases the outlet of the drains is into the sea. The sewage of Exmouth passes, by an open drain, along the foreshore as far as low-water mark, which is within 70 yards distance of the public bathing-place. At Brighton the ladies are subjected to a similar arrangement. At Southsea, again, the mouths of the sewage-pipes open close to the pier, and to the bathing machines. The county surveyor at Somersetshire, who has paid much attention to the drainage of towns, gives a most deplorable account of the condition of some of the western towns. In the rising watering place of Weston-super-Mare all the sewage runs into one of the rhynes or open ditches which drain the marshland of the district. The water in it is so foul that the cattle will not drink it. The river Tone is poisoned by the sewage of Taunton. The river Frome in many places is in a disgusting condition with respest to the water and the deposit along its banks. Indeed, the evidence in this respect gives most abundant proof that our rivers are everywhere being silted up by deposits of cinders and sewage, and that nobody interferes, the reason in many cases being, according to the evidence of Mr. Tom Taylor, the Secretary of the Local Government Board (3897), that the persons who create the nuisance are themselves members of the local boards whose duty it is to conserve them. That it is a nuisance at common law to discharge sewage into a river has been decided, but where it is only a public nuisance there is no one to put the law into operation. When, however, direct injury is done to the property of any individual, local boards can be restrained

from polluting streams by injunction. Indeed, several Boards of Health have been stopped in this manner. At Uxbridge, for instance, Colonel Tower obtained an injunction against the board for poisoning his fish in the river Coln with the sewage; at Hitchin the local board was restrained in a similar manner, and so terrified were the members at the penalties threatened by the law, that they resigned, and there is now no board in the town. At Croydon the board have suffered 6 or 7 injunctions, and have been so embarrassed with their sewage that they have absolutely been forced to do what they should have done in the first instance, and which has made them the example to every other town in England—they have turned it on to the land at a profit. When we remember that every farmer is compelled by his lease to consume upon his land all the manure produced upon it, it does seem extraordinary that a reverse rule should obtain when human beings are concerned. And we think we are justly open to the reproach cast upon us by Leibig, who accuses us of wilfully casting forth into the ocean those fertilizing elements we have drawn not only from our own fields, but from those of Europe and the whole world.

But Croydon, we say, has solved the difficulty Bramah has slowly brought about by the introduction of the water-closet. His invention emptied the cesspools into the rivers, and for a time robbed the land; for of old their contents were returned to it in a very disgusting and costly manner. His invention now enables the sewage to carry itself on to the land. At Croydon, being stopped by injunction from throwing the sewage into the Wandle, the local board leased 240 acres of land at £4 an acre, turned their sewage upon it, and relet it for £5 an acre. Thus they make a clear profit of £240 a year, and enormous crops are got off the land, which serves as a pattern-card, as it were, to the surrounding farmers to the value of sewage. Moreover, there appears to be good reason to believe, that at least another hundred acres may be profitably employed, considering the heavy dressings placed on the land by the present tenant. This would yield £340 a year, which would go in diminution of the rates. It is true that Croydon is favorably situated for the distribution of its sewage, as it stands on a height, and it can therefore be distributed by means of simple gravitation; but there are hundreds of towns in England just as favorably placed; and with this example before their eyes, of turning this heretofore considered public nuisance into a source of profit, it is really disgraceful that they should any longer pollute our rivers with it. The importance of the principle of placing entire watersheds under the control of some central board is most clearly set forth in the evidence published in the volume before us, but there appears to be a very general agreement of opinion that the functions of boards appointed for such catchment basins should be merely to supervise the action of the local boards within their district, and to enforce obedience to the law, leaving the necessary works to be carried out by the local boards alone. In short, that fear of centralization which is ever before the eyes of Englishmen, and which has led to evils almost as great in some cases as those it wishes to avoid, is clearly evinced

by all those who have given evidence upon this very important subject. The committee in their report have embodied their opinions upon it in the following paragraph:

"We recommend that the important object of completely freeing the entire basins of rivers from pollution should be rendered possible by general legislative enactment, enabling the inhabitants of such entire districts to adopt some controlling power for that purpose; but it should include a provision for compelling local boards to render the sewage of their districts innocuous by application to the land for agricultural purposes. The case of the valley of the Thames (where the purification of the river has been sought by the expenditure of enormous sums, is, to a considerable extent, counteracted by the increased discharge of sewage from towns higher up the stream) requires special and immediate attention."—*The Times.*

On the Elastic Force of Steam. By Prof. POTTER, A.M.*

From the London Mechanics' Magazine, February, 1865

The following article is an examination of the applicability of Mr. Alexander's formula for the elastic force of steam, to the elastic force of the vapors of the liquids as found by the experiments of M. Regnault.

To those who are investigating the development of the mechanical force which arises from the action of the subtle agents causing the phenomena of heat, electricity, magnetism, &c., upon dense matter, the law of the elastic force of vapors in contact with the liquids from which they arise, at different temperatures, is a subject of great importance.

Many formulæ have been proposed for the elastic force of steam, which corresponded sufficiently nearly with the observed results through moderate ranges of temperature, but failed completely for great ranges. It is not intended in the present paper to recapitulate these attempts.

M. Regnault has given formulæ for interpolation which enabled him, from his observation through many series of experiments, to construct most valuable tables of the elastic force of the vapors of the liquids in regularly ascending temperatures. These are found in his treatise "Relation des expériences . . . . pour déterminer les principales lois et les données numériques qui entrent dans le calcul des machines à vapeur. Par M. V. Regnault," in two volumes, of which vol. i. is tome xxi., and vol. ii. is tome xxvi. of the Memoirs of the Institute, but the two volumes can be procured as a separate treatise; and from a recent paper in the *Philosophical Magazine* they appear not yet to be much studied in this country.

However valuable interpolation formulæ may be for the purposes to which they are applied, yet in physical inquiries we naturally seek for formulæ which are likely to represent the physical laws of the phenomena; which will generally be simpler than the expansions in series

* Communicated by the author, to the *Philosophical Magazine* for February, 1865.

with coefficients to be determined from the experiments, which is the constitution for the interpolation formulæ.

In the number of the *Philosophical Magazine* for January, 1849, there is an important paper, reprinted from *Sillinan's American Journal of Science* for September, 1848, and entitled "On a New Empirical Formula for ascertaining the Tension of Vapor of Water at any Temperature. By J. H. Alexander, Esq." In this paper is a table occupying four pages, in which the results of the formula are compared with the observations of Regnault, 1844; the Franklin Institute, 1836; the French Academicians, 1829; Taylor, 1822; Arzberger, 1819; Ure, 1818; Dalton, 1801 and 1820; Southern, 1797 and 1803; Betancourt, 1790; Robison, 1778; and Watt, 1774. Though the formula shows considerable differences from even the more recent experiments in some cases, yet the differences are not more than are found between the experimental results themselves of the different observers at nearly the same temperatures. As the range of temperature is from — 27° ·112 to 435° ·227 Fahr., through which the general accordance of the formula with the experiments holds good, we must admit the argument of Mr. Alexander, that his formula accords with the observations of the different observers as closely as they accord with each other, to be conclusive.

When we consider the formula, we can see that the nature of the experiments must be such that extreme accuracy is unattainable with even the most improved apparatus. When p is the elastic force of the vapor expressed in the pressure of a column of inches of mercury, t the temperature expressed in Fahrenheit's degrees, then Mr. Alexander's formula is $p = \left(\frac{t}{180} + \frac{990}{1695}\right)^6$. The binomial being to the sixth power, a small error in the value of t, either in the graduation of the thermometers or in the observations, produces a considerable change in the value of p; and if both errors existed at the same time and in the same direction, the error in the value of p might become large. We have no need to be surprised that even the results of M. Regnault require this consideration to be kept in mind, and it is the general accordance through long ranges of temperature that we must look for, rather than great accuracy at all points, which the subject is not capable of giving.

Having long ago compared Mr. Alexander's formula with the results for the elastic force of several vapors given at page 298 of Dalton's "New System of Chemical Philosophy," part 1st of volume ii., and found the accordance satisfactory, I have lately undertaken the comparison with M. Regnault's results in the second volume of his *Relation des Experiences*, &c., pp. 374 and forwards. The result of these investigations is contained in the following remarks.

To adapt Mr. Alexander's formula for the elastic force of steam to that of the vapors of other liquids, let p be the pressure, let a and b be constants, and t the temperature, then we have

$$p = (a + bt)^6.$$

Now, M. Regnault's results give p in columns of millimetres of mercury, and t in Centigrade degrees; so that I shall give the procedure and results in these terms at first, and afterwards show the formulæ for p in inches of mercury, and t in Fahrenheit's degrees.

For *vapor of alcohol*, in the formula $p=(a+bt)^6$, putting $t°$ C.$=0$, at the freezing point of water, M. Regnault found

$$p=12{\cdot}70 \text{ millims.}=a^6;$$
$$\therefore a=1{\cdot}527451.$$

Again, at 150° C. he found

$$p=7318{\cdot}40 \text{ millims.}=(1{\cdot}527451+150b)^6;$$
$$\therefore b=\cdot0191920.$$

With these values in the formula $p=(a+bt)^6$ the numbers in the third column of Table I. were calculated; the second column contains M. Regnault's corresponding results, from his table at page 374 of vol. ii.

TABLE I.

Temperature Centigrade by air-thermometer.	Elastic force of vapor of alcohol by interpolation formula.	Calculation by Alexander's formula.
Deg.	Millims.	Millims.
— 20	3·34	2·237
— 10	6·47	5·674
0	12·70	12·700
+ 10	24·23	25·836
20	44·46	48·748
30	78·52	86·556
40	133·69	146·166
50	219·90	236·651
60	350·21	369·665
70	541·15	559·887
80	812·91	825·507
90	1189·30	1188·750
100	1697·55	1676·423
110	2367·64	2320·517
120	3231·73	3158·836
130	4323·00	4235·640
140	5674·59	5602·368
150	7318·40	7318·395

The general accordance of the second and third columns through the range of 170° Centigrade is, I think, sufficient to warrant the conclusion that the elastic force of the vapor of alcohol is represented by the formula $p=(a+bt)^6$; and further research might furnish values of a and b which would produce greater accordance.

For the *vapor of ether*, taking the temperatures $t°$ C.$=0$ and $t°$ C.$=100°$ to find the values of a and b in the formula $p=(a+bt)^6$, we find

$$a=2{\cdot}385739,$$
$$b=\cdot01742984,$$

TABLE II.

Temperature Centigrade by air-thermometer.	Elastic force of vapor of ether by interpolation formula.	Calculation by Alexander's formula.
Deg.	Millims.	Millims.
— 20	68·90	71·471
— 10	114·72	116·964
0	184·39	184·390
+ 10	286·83	281·500
20	432·78	417·937
30	634·80	605·528
40	907·04	858·585
50	1264·83	1194·238
60	1725·01	1632·774
70	2304·90	2198·009
80	3022·79	2917·681
90	3898·26	3823·840
100	4953·30	4953·296
110	6214·63	6348·050
120	7719·20	8055·800

which give the results in the third column of Table II.; and the second column contains M. Regnault's corresponding results, from his table at page 393, vol. ii.

The general accordance of the second and third columns through a range of 140° C., for so volatile a liquid as ether, is, I think, sufficient to show that the elastic force of its vapor is represented by the formula $p = (a + bt)^6$.

TABLE III.

Temperature Centigrade by air-thermometer.	Elastic force of vapor of sulphuret of carbon by interpolation formula.	Calculation by Alexander's formula.
Deg.	Millims.	Millims.
— 20	47·30	50·240
— 10	79·44	81·634
0	127·91	127·910
+ 10	198·46	194·245
20	298·03	287·066
30	434·62	414·231
40	617·53	585·230
50	857·07	811·400
60	1164·51	1106·146
70	1552·09	1485·185
80	2032·53	1966·785
90	2619·08	2572·043
100	3325·15	3325·144
110	4164·06	4253·690
120	5148·79	5388·924
130	6291·60	6766·143

For the *vapor of sulphuret of carbon*, taking the temperatures $t°$ C. $= 0$ and $t°$ C. $= 100°$, we find the values of a and b in the formula $p = (a + bt)^6$ as follows:

$$a = 2{\cdot}244660,$$
$$b = \ {\cdot}01618729,$$

which give the results in the third column of Table III., M. Regnault's corresponding results (from his table at p. 402, vol. ii.) being given in the second column.

The general accordance of the second and third columns is again sufficient to lead to the conclusion that the vapor of sulphuret of carbon has its elastic force represented by the formula $p = (a + bt)^6$.

For the *vapor of hydrochloric ether*, determining the constants a and b in the formula $p = (a + bt)$ from the experimental results at the temperatures 0° C. and 100° C., we find

$$a = 2{\cdot}783579,$$
$$b = \ {\cdot}01753492,$$

which give the results in the third column of Table IV.; and M. Regnault's corresponding results, from his table at page 446, vol. ii., are given in the second column.

TABLE IV.

Temperature Centigrade by air-thermometer.	Elastic force of vapor of hydrochloric ether by interpolation formula.	Calculation by Alexander's formula.
Deg.	Millims.	Millims.
— 30	110·24	132·374
— 20	187·55	207·360
— 10	302·09	314·829
0	465·18	465·180
+ 10	691·11	671·130
20	996·23	948·035
30	1398·99	1314·236
40	1919·58	1791·426
50	2579·40	2405·017
60	3400·54	3184·566
70	4405·03	4164·196
80	5614·11	5383·030
90	7047·51	6885·700
100	8722·76	8722·754

The general accordance of the second and third columns warrants us in concluding that the elastic force of vapor of hydrochloric ether is expressed by the formula $p = (a + bt)^6$.

M. Regnault's experiments on the elastic force of the *vapor of essential oil of turpentine* extend from 0° C. to 200° C., and by calculating the constants a and b from the pressures at 0° C. and 100° C., the formula does not well accord with the observations; and taking the observations at 50 °C. and 150° C. to determine the constants,

the results of calculation and observation diverge greatly also; but taking the pressures at the temperatures 100° C. and 200° C. to determine a and b, the formula shows a general accordance with the results of observation, with, however, occasional differences of considerable magnitude. These latter give

$$a = 1{\cdot}029373,$$
$$b = {\cdot}01224551,$$

with which the results in the third column of Table V. were calculated; and M. Regnault's corresponding results, from his table, page 501, vol. ii., are given in the second column.

TABLE V.

Temperature Centigrade by mercurial thermometer.	Elastic force of vapor of oil of turpentine by interpolation formula.	Calculation by Alexander's formula.
Deg.	Millims.	Millims.
0	2·07	1·190
10	2·94	2·335
20	4·45	4·281
30	6·87	7·425
40	10·80	12·294
50	16·98	19·574
60	26·46	30·140
70	40·64	45·084
80	61·30	65·750
90	90·61	93·772
100	131·11	131·110
110	185·62	180·092
120	257·21	243·458
130	348·98	324·406
140	464·02	426·640
150	605·20	554·419
160	775·09	712·615
170	975·42	906·760
180	1207·92	1143·114
190	1473·24	1428·722
200	1771·47	1771·470

Though the differences in the above table are in some cases large, yet I think the general accordance of the second and third columns is sufficient to warrant our concluding that the elastic force of vapor of oil of turpentine is expressed by the formula $p = (a + bt)^6$. This last example shows that it is not safe to take *any two* observed pressures and temperatures for the purpose of determining a and b from the tables, but the values obtained should be applied to the other temperatures and pressures before we can rely upon them.

As the computations are tedious, I shall not proceed further at present with the numerous vapors examined by M. Regnault, having satisfied myself that the elastic force of the vapors generally is expressed by Mr. Alexander's formula.

For the six liquids of which the elastic forces of the vapors have now been shown to be expressed by the formula $p = (a + bt)^6$, we have the following formulæ for p expressed in inches of mercury and t in Fahrenheit's degrees :

For *steam* or vapor of water (Mr. Alexander's formula in decimals),

$$p = (\cdot 5840708 + \cdot 00555555\, t)^6.$$

For vapor of *alcohol*,

$$p = (\cdot 691898 + \cdot 0062885\, t)^6.$$

For vapor of *ether*,

$$p = (1\cdot 210775 + \cdot 00564785\, t)^6.$$

For vapor of *sulphuret of carbon*,

$$p = (1\cdot 141374 + \cdot 005245224\, t)^6.$$

For vapor of *hydrochloric ether*,

$$p = (1\cdot 441730 + \cdot 005681901\, t)^6.$$

For vapor of *oil of turpentine*,

$$p = (\cdot 4734178 + \cdot 00396796\, t)^6.$$

Fresh researches would probably lead to small modifications of the values of the constants, but I do not think that large changes would be found necessary.

Facts and Fallacies as to Tubular Boilers.

From the London Practical Mechanic's Journal, February, 1865.

Steam boilers—crude, ugly, inefficient, wasteful, and unmanageable, as they so generally prove—are yet amongst the most important material things to which an Englishman's mind can be directed ; for, upon these big kettles, as the Germans literally call them, has depended a good deal of the national prominence of position and power we hold in the world, and a far larger proportion of British greatness must, year after year, be found dependent upon these unwieldy utensils.

Any competent man who will say a word of new truth on such a subject, should be accepted on all sides with the gratitude that becomes a benefactor, large or small ; but if the subject be thus important, in the like proportion is the man who rushes in and, by ill-considered assertion or misinterpreted experiment, "darkens counsel by words without knowledge," deserving of deprecation.

Especially is this so when such communications come from one whom the half-educated, who constitute the mass, in some way accept as an authority, whether justly or unjustly we will not now enquire.

These remarks have been suggested to us by the perusal of a pamphlet (a work, probably, we ought politely to call it) by Mr. Charles Wye Williams, published by Spon, London, "On the Steam Generating Power of Marine and Locomotive Boilers."

The production consists of but 25 quarto pages, and, although we nowhere gather such to have been the fact, was probably originally a paper read before some provincial society ; yet within an equal number of pages we think it would be difficult to compress a greater

amount of ignorance of physics, and misinterpretation of experimental facts.

And yet the subject is one of the simplest character, and one upon which not only have all capable mechanical engineers long possessed well-defined ideas and clearly settled conclusions, which they act upon every day of their lives, but which are day by day proved to be true, by the tests of actual practice.

Were it not that Mr. Williams has acquired a sort of quasi-scientific reputation as a great Prophet of Smoke, we should not have thought it worth while to notice this last product of his very ready pen at all, content to let it, of its own weight, drop into that oblivious place where all error finds itself at last.

We recollected, however, that when a former, and, if we mistake not, the ante-penultimate production of Mr. Williams' pen, his "Heat in its Relation to Water and Steam," in 1862, made its appearance, there were a good many who might have been expected capable of appraising it at its just value, but who were, for a time at least, staggered and uncertain as to one or to all of the many astonishing misconceptions of physics with which that work abounds, and who really seemed to think that perhaps a prophet had risen up amongst us so profound that his utterances were as yet not understood fully of the uninitiated. In fact, there is a certain sort of philosophy that has a positive tendency to muddle other men's brains.

This present *brochure* of Mr. Charles Wye Williams is precisely of that sort and quality, and hence it is not amiss to analyze and point out briefly its leading mistakes. The first chapter, "On the Assumed Value of Tube Surface," begins thus: "It will doubtless hereafter be a matter of special wonder, when the construction of boilers shall have been perfected, to find that for 34 years, since Stephenson's *Rocket* won the prize for the locomotive, we have been following an *ignis fatuus*—the so-called heating surface of tubes; and that so far from that surface being the measure of the heat-transmitting and evaporative power, it may, in fact, be altogether omitted in our calculations, and for the measure of that power we shall have to look to a different part of the boiler—a portion hitherto absolutely unnoticed and unappreciated by engineers. The experiments and proofs hereafter detailed fully establish this fact beyond question."

So far the statement is that the tubes of tubular boilers (locomotive or marine) are, as a means of conveying the heat of the products of the burnt fuel to the water, absolutely valueless.

The next paragraph surpasses our comprehension as to any distinct idea it conveys.

"Of the tube internal surface, as regards its heat-transmitting and steam-generating property, we may, as will hereafter be shown, on the authority of the late Mr. Dewrance and Mr. Hick, of Bolton, estimate its efficiency in comparison with that of the furnace or fire-box plates at but one-tenth of the gross nominal surface it presents, where the tubes are not more than six feet long. My own numerous experiments and observations fully bear out this statement." "Again, when the

tubes are ten feet long and upwards, we will not err much if, with the exception of the first *twelve inches*, we leave them altogether out of our calculation, and regard them as mere conduits for conveying the heated products of combustion to the chimney."

So, then, with tubes of 6 feet long, ten super. feet of tube is equal to one of fire-box; but tubes of any greater length, however great their total surface, we may consider as worth nothing, except the first foot of their length, and leave all the rest out of calculation altogether!

So far for the *ignis fatuus* that engineers have been foolishly relying upon for 34 years as having something to do with the steam raised in locomotives, &c.; such is their sin of commission, according to Mr. Williams. Let us now come to their sin of omission—"the portion of the boiler which has been absolutely unnoticed and unappeciated by engineers."

Here we have it. "Against the insufficiency of the tubes, as heat transmitters and steam generators, we have the hitherto neglected surface of the *face-plate*, presenting a face to the direct action of the hot current of the furnace. Assuming the orifice of the tubes occupy one-fourth of the gross area of the face-plate, the practical heat-transmitting portion will be the remaining three-fourths."

"Hitherto the face-plate has been regarded as a mere mechanical contrivance by which the tubes were held in their places, for preserving certain distances between them, to enable the water to surround them.

"Strange to say, no idea whatever appears to have been entertained that the face-plates had any heat-transmitting or steam-generative property *of their own*."

To many of our readers the term *face-plate* will be new and without a distinct meaning. We may, therefore, here say, that the author's *face-plate* means that side of the fire-box of a boiler on the locomotive construction through which one end of the tube passes.

In Mr. Williams' *strict* sense, it is only that portion of the plate forming this side of the interior of the fire-box which is not cut out by the perforations for the ends of the tubes. It is, therefore, the unperforated surface of the tube-plate of the fire-box. We may therefore at once dispose of the sin of omission charged against locomotive and other engineers by declaring it simply a mare's nest.

It is not a fact that *any part of the interior surface* of fire-box in locomotive boilers has been unnoticed and unappreciated by engineers. We could point to scores of examples, were it necessary so to support the universal cognizance of all those engaged in proportioning such boilers, proving that *all parts* of the interior of the fire-box, every square inch of its surface, is and always has been habitually taken into calculation, and its effect allowed for; and hence this tube-plate, or *face-plate*, as Mr. Williams is pleased to call it, as a matter of course, included.

Although he does not say so in words, Mr. Williams is obviously of opinion that this *face-plate* does nearly all the work of the whole fire-

box; or, to be strict, so as to avoid injustice, he distinctly infers that each square foot of interior surface of this face-plate (at a given level in the fire) is vastly more effective than any equal area of any other of the three sides of the fire-box, or of its roof.

"We here at once recognise the cause of the great steam generative power of the *single face-plate* in each locomotive, namely, the almost electric rapidity of the draft of the chimney, producing a correspondent increase in the force with which the heated current strikes that plate."—Page 4.

And a little further on—"The effect produced by the direction in which the heated current strikes the surface may aptly be compared to the rolling of a cannon ball rapidly along a sheet of ice, as compared with letting it fall vertically upon its surface. The simile is perfect; for in proportion as the rapidity of the motion of the ball along the plane of ice is increased, so will its effect be *diminished*, whereas, as the rapidity with which it falls is *increased* so also are its effects."—Page 5.

Alas for the men who bring *similes* into science. Here is the old blunder in mechanics—the attempt to compare *pressure* with *vis-viva*. The *effect* of the ball rolling along the ice is simply equal to its weight, and the pressure due to its weight upon the ice in contact with it at any instant will be the same, whether the ball roll fast or slowly. Mr. Williams' proposition involves this exquisite mechanical consequence, that the ball *loses weight* in proportion as it rolls faster, and that if it rolled with an infinite velocity it would cease to have any weight at all. Again, as the ball rolling along the ice has no vertical velocity at all, *i.e.*, is, as regards the vertical, absolutely at rest, we are somewhat at a loss to see how we can compare its vertical *effect* on the ice with that of a like ball dropping with more or less vertical velocity upon the ice. In a word, how we are to compare the weight of the ball with its weight multiplied by the square of its vertical velocity, M, with MV^2, where, by the conditions, we cannot get rid of V on the one side, and it cannot exist at the other.

But we make no doubt all this would seem very undemonstrative to the author, so we will pass to the use he makes of it as a *simile*.

He obviously is of opinion—indeed he distinctly affirms what amounts to this—that a given volume of heated air of given density arriving at and passing off from a given plane surface of a body of constant temperature and receptive of heat from it during a given time, must communicate more of its heat in this time, if the direction of motion of the heated air be perpendicular, than if it be parallel to the receptive surface.

Now, to fix our ideas, let us just ask Mr. Williams this question: Suppose a square tube of cold boiler plate, of 10 feet long by a foot square, placed in a vacuum, and that a red-hot cannon shot of say 1 pound weight were to pass along the axis of the square tube at the rate of say 1 foot per second.

He would *perhaps* admit that the total heat lost to the ball and received by each of the four sides (two vertical and two horizontal) of

the tube would be the same. Let us call this quantity for any one side, on the unit of surface (1 square foot)=10.H.

Now, suppose a boiler plate of 1 foot square, of like thickness and temperature, to be passed parallel to itself, through the tube and square to its axis, at the rate of 1 foot per second, and always in a position 6 inches in advance of the red-hot shot.

We ask, would not the total heat delivered into this square foot of plate be also exactly = 10·H., assuming, as we must do, that the difference of temperature at the commencement between the shot and the plate remained constant?

Now, the shot here is the representative of any one of the particles of hot air that move against the face-plates and through the tubes parallel to their interior surfaces.

To be brief, Mr. Williams confuses *radiation* and *convection*. The former has nothing to do with position, except as regards the angle made with the ray by the receptive surface; upon the latter (in the matters before us) depends the question of how many radiating particles are carried per unit of time within the same mean distance of the receptive surface.

This confusion of thought is made quite unmistakable by a passage of page 10. After having taken to task Mr. Clark and Mr. Z. Colburn, who, in his excellent work on Locomotive Engineering, has sinfully ignored these wonderful properties of "face-plates," the author proceeds:

"In his work, Mr. Colburn speaks of a 'generator in which the heated products of combustion are split up into numerous streams by tube-flues.' The supposed value of this splitting of the heated products of combustion into numerous streams is based on a serious mistake in supposing that those small attenuated streams had the faculty of giving out heat laterally to the course of those streams.

"Now, it is well known that rays of heat or light do not radiate *laterally to their course*, and that their effect depends on their striking in a vertical direction, or as near to that as possible. As well might we suppose that the rays of the setting sun, as they pass beside us, on the line of the earth's surface, . . . were equally powerful with those that strike downwards with vertical force at noon; or that a cannon ball glancing along the side of an iron-clad steamship, and in the line of its iron plates, would have equally destructive force with one striking in a point-blank direction and vertical to those plates."

The italics above are ours. We pass by the confused use of the word vertical, intended no doubt for perpendicular to the course of the ray, although the appeal to the vertical *sun* does seem to suggest a suspicion that the writer fancies perpendicularity to the horizon has something to do with radiation; and by the words in italics we see at once that he confounds the *direction of radiation from the particles* of a stream of heated matter, with the *direction of motion of the stream itself*.

Is it true that there is no radiation of heat from and perpendicular

to the sides or top of a stream of liquid cast iron, or that there is not just as much radiated from an unit of surface, perpendicular to the direction of motion of the stream, as there would be from the same unit of the square advancing end of the stream, were it practicable to so arrange it? If so, then let us revert to Mr. Williams' own example—the sun—and ask him what is the cause of the *diffused* light of day?

It is wearisome to dissect this sort of stuff. Mr. Williams has not thrown any light on the subject of the locomotive boiler. From at least the year 1834, if not earlier, the fact was clearly ascertained and recognised that, unit for unit of surface, the fire-box was greatly more efficient in passing heat into the water than the tubes. It is so for many reasons, mainly because the receptive surfaces of the fire-box are, as respects *radiation* from the incandescent fuel, much *nearer* to particles at the highest temperature than any other part of the boiler, and the effect of radiation is greater inversely as the *square of the distance*, and as respects *conduction*, because the plates are here in actual contact with white hot coke.

It has also never admitted of a question, on the part of any competent engineer, that as respects *convection*, each square inch of the various parts of the interior of the fire-box is more effective, in proportion as a larger volume of gases, heated to a given temperature, passes it by or reaches it in whatever direction in a given time. From this last it is no doubt true, that all that part of the fire-box towards which the heated gases of the fire pass in order to enter the tubes, must have more heat brought to them in a given time than to the opposite parts nearer the fire-door. But that is all, and does not specially or solely apply to the tube-plate (or face-plate of Mr. Williams); it is equally true, *pro tanto*, of the roof of the fire-box.

To jump to the conclusion from this, that the tube-plate does all or nearly the whole of the work of the whole interior of the fire-box, is simply nonsense. To endeavor to sustain such a notion by misinterpreted experiments and ill-understood physics, is to indicate an incapacity for dealing with such questions at all.

The comparative small efficiency of the tubes, again, has been for years fully recognised and understood. It mainly arises from the facts—first, that the temperature of the particles of the radiating streams of heated gases swept through them is greatly below that of those particles while in the fire-box (where they are robbed of much of their heat); and, secondly, that the draft is obliged to be so sharp, in order to maintain the high temperature of the fire, that there is not *time* enough during the transit through tubes of ordinary length for the gases to radiate all or even the greater part of their heat.

This is proved by the tremendous temperature of the smoke-box and even the top of the funnel of every locomotive; and, to any sane man, this fact is an argument cogent and inexpugnable for lengthening out the tubes, so as with the same velocity of draft to give *more time* for radiation within the tubes.

And here comes in the second and most extraordinary error, namely,

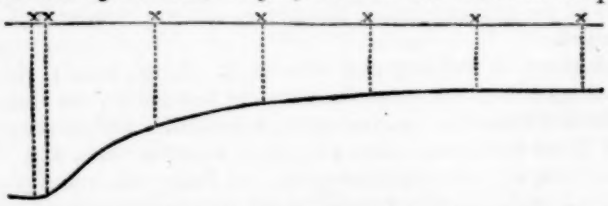
that only the first few inches of the tubes are of any use whatever, and that in place of lengthening we should shorten them.

To put in its true light this fallacy, we need do no more than reproduce here Mr. Williams' own first experiment. He had a boiler constructed in which a *fasciculus* of tubes 5 feet in total length was separated by plates at intervals, so that, he says, "the heat-transmitting value of each lineal foot of the tube would be indicated." The compartment next to the *face-plate* was only one inch in length, the second was 10 inches in length, and the four subsequent ones were 12 inches in length each. After three hours work, the following quantities of water had been evaporated from

	Lbs.	Oz.
Compartment No. 1 (1 inch long) . .	2	14
Do. No. 2 (10 ") . .	2	15
Do. No. 3 (10 ") . .	1	14
Do. No. 4 (12 ") . .	1	6
Do. No. 5 (12 ") . .	1	2
Do. No. 6 (12 ") . .	1	1

We take it that every one will see that the first compartment of 1 inch long is in reality not that of an inch of tubes only, but of the face-plate or tube plate surface also. In fact, the heat taken up by the relatively large mass of metal in the tube-plate next the fire is rapidly given up to the water in contact with it and the first inch of tube. And were it worth while to expend space in further quotation we have proof in the facts given, how much, in this first compartment, the action of tube and tube-plate are confounded.

We shall pass by also, what most persons will perceive, that horizontal tubes thus diaphragmed off into a number of separate chambers are no longer in the same, or in as favorable a position, as in an ordinary boiler where the *water is free to circulate* in all directions, and to sweep *along* the tubes from the cooler to the hotter end, in the *reverse direction* to the current of heated gases passing through them. We simply propose to plot into a curve, as below, the author's own result; and let any man ask his own eye if this curve (which represents the efficiency, admitting Mr. Williams' condition, in relation to the length of the tubes) does not conclusively prove, that after the first three or four feet in length from the fire, the total effect of the tubes is *almost directly as their length, and as the residual temperature*



of the passing currents of heated gases. In fact, for the last three feet, the absorption of heat from each foot of the tube is very nearly uniform, almost quite so for the last two, and would obviously have proved still more so had the tubes been prolonged for three feet fur-

ther. Yet, in the face of this obvious deduction from his own experiment, what is Mr. Williams' conclusion? "Here we have an unquestionable confirmation of the valueless character of the last four feet of the tube." We may let this speak for itself.

It would be tedious and demand space we can better appropriate, to persue the remainder of these pages through the ill-devised or misinterpreted experiments with short tubular boilers, put after each other in succession, with spaces or combustion chambers between. They are but complications of the primary mistakes, and not worth disentangling. Nor need we show the want of foundation of what is pompously termed the "Law for Regulating the Applications of the Face-plate Surface," this *law* being, that (in *all* boilers, as we understand him, locomotive and marine) we are to provide one square foot of effective face-plate surface for an equal area of grate surface. The magnificent title of a *law* is fitly commented by the nearly concluding sentence of the chapter. "How far this law may hereafter be modified, will be the result of future practice."

That practice should be determined or modified by law, (natural law,) we have always thought; but that a natural law should be modified by practice, and that it should be uncertain how far it may be modified (even to zero perhaps) by practice, does to us sound a little paradoxical.

The remaining two chapters of this production we shall pass wholly, viz: "On the Application of the Steam in aid of the Draft," and "On the Use of Coal in Locomotive and Marine Boilers." They have no direct concern with what has preceded them, and their "stuff and substance" might be not unjustly indicated in the words of Blumenbach, as applied to phrenology with a slight alteration: "There is little in them that is new or true, and that which is new is not true."

The practical upshot (if there be any) of Mr. Williams is, that tubular boilers should be constructed of consecutive drums of short *fasciculi* of tubes, arranged with delaying spaces or combustion chambers between them. This is, in fact, what he means by his "law of the face-plate." Within certain limits, but for reasons widely different from anything that Mr. Williams has advanced, we have little doubt that by such a method, *where practicable*, not only the total surface but the efficiency of the unit of parts of the surface in some tubular boilers may be increased.

In this there is nothing new whatever. Large tubular land and even marine boilers may be at this moment pointed to, that have been a considerable time at work, and which consist of a succession of large drums of tubes with combustion chambers between each, and the fire at one or even at both opposite ends. In these the velocity of the draft is moderate. If this velocity *must inevitably* be rapid and cutting, as in the locomotive boiler, then such breaks in the length of the tubes are, for various reasons, *impracticable*—physically so, because they destroy the rapidity of draft by their increased resistance;—mechanically, because inadaptable to the necessities of structure in the locomotive engine.

As for marine boilers, the day will come when fresh water alone will be employed, and then the directions for improvement will be to follow, as far as possible, in the track of the boiler of the locomotive.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

Work and Vis-viva. By De Volson Wood, Prof. C. E., University of Michigan.

The object of this article is to make some comments upon one published by Mr. Nystrom, upon the same subject, in the last March number of the *Journal.* Had he not grossly misrepresented me in at at least two points, in his criticism upon a former article of mine, it would hardly be necessary for me to reply to him, for I observe that his reasoning upon all the new matter of the article, is remarkably correct, and his ideas more definite, agreeing essentially with mine, and hence, as he observes, with the standard authors of the day.

He opens upon me with a masked battery in the form of an explanation, and then pours in a cross-fire in the form of cant phrases, until the casual reader might suppose that my arguments were annihilated; but the sequel will show that he has merely exposed his position at several vulnerable points, no one of which can stand a fierce assault.

He says, I have misconceived the meaning of the letter V, and says it means *mean* velocity. I willingly accept the explanation, but am I to blame for the misconception? Did he so limit it in the preceding article? Did he not use it at one time as a constant, and at another as a variable, without any mention of the double usage? And if so, does it tend to avoid "the great confusion which now involves the subject?"

In the next paragraph he makes a correction, which I gladly accept. I should have said in the case referred to, that the work $= \frac{1}{2}$ F V T.

In the following paragraph he thinks that my expression "F T = S," should be F V = S. Mine is evidently a misprint, and I presume his is also; for it should be V T = S.

Having cleared up these minor points, we proceed to the more important criticisms.

I have said, and he quotes the same, on page 181, that the equation F V T = M V^2 is a true equation without expressing the value of work. Then the writer adds: "Is it possible that the formula can be a true *equation of work*, without expressing the value of work?" In this he plainly intimates that I have called it "a true equation of work." Have I said so? Has my language *intimated* it? Is not this putting words into my mouth, and then taking advantage of them? Is it making a fair representation of my meaning? He then says: "I (Mr. Nystrom) contend that it expresses the true relation between work and *vis-viva*," and afterwards proceeds to prove it. Let us see how he proves it. He commences the proof in the latter part of page 183.

He takes the case of a body free to move and acted upon by a constant force F, during a time T, at the end of which it has acquired a velocity V. He then truly finds $F V T =$ *twice* the work done upon the body. See equation 7, p. 184. If, now, M be the mass of the body, moving with the velocity V, $M V^2$ equals twice the work. See equation 8, p. 184. It also equals the *vis-viva*, as he says a few lines below. Hence, in the equation $F V T = M V^2$ one member *is the vis-viva*, and the other *is not the work;* does it then express the true relation between work and *vis-viva?* and if not "whose reasoning must be very elastic?"

In regard to this equation the writer says, p. 184, that I "proved it to be '*an absurdity under every hypothesis.*'" Now, by referring to my article, p. 27, present volume, or even to his extract of it as given on p. 181, it will be seen that he has omitted the phrase, "except the first," which should immediately follow the above quotation; and hence would read, "*proved to be an absurdity under every hypothesis except the first.*" What was this *first hypothesis?* It was "that the body be free to move, and acted upon by a constant force." An examination of Mr. Nystrom's article, pp. 183 and 184, shows that this is *the very hypothesis* which *he* has used in establishing the equation under consideration. I leave it for the careful, candid reader to judge "whose reasoning must be very elastic." This may be a sharp way of showing up a writer, but is it the way "to advance cautiously?" Does it aid in removing "confusion?" Does it savor of that "due deliveration" which is essential to true "reform?"

It should be observed, still further, in regard to this equation, of which so much has already been said, that it is a true equation only when the body is free to move, and under a constant force. If the force varies as the distance, square of the distance, or inversely as the distance from some point, then it will not be true. So Mr. Nystrom gives a differential expression for work, on p. 184, which is

$$dW = F\, v\, dt,$$

the integral of which gives the work. Letting G be the acceleratrix, and he makes $v = G\, t$. Is this true, except when G is constant? and if not, is the expression

$$W = \int F G\, t\, dt,$$

on p. 186, true when F and, consequently, G is variable?

Will we find by solving it that the figure of work, when the force varies as the square of the velocity, is a regular pyramid, with right lines for its edges?

Is not momentum the *mass* multiplied by the velocity? and if so, should not the expression on p. 186 be

$$\text{Momentum}, \frac{M}{g} V = \int V\, dt,$$

in which M is the *weight* of the mass?

On p. 183 he says: "It is perfectly absurd to say with myself and others '*that work is independent of time.*'" Why, then, does Mr. Nystrom say on p. 327, vol. xlviii, that "the foot-pounds of work means

so many pounds raised through a space S, *independent of the time.*" But now he tries to show the absurdity by begging the question, and reasoning from my stand-point. He says, according to my reasoning "force is independent of work," &c.; but I suppose he means that *work is independent of force*, and adds, "a force of one pound can accomplish as much work as a force of 100 pounds; but at the expense of time and velocity only." This is true, and is no more than I contended for, which was, that the work is always the same when the expression F S gives the same quantity, whatever be the relation of F and S, or V and T. Will the writer contend that because he contracts to dig a canal in six months, and completes it in three months, that, therefore, he has done only one-half the work? Have I *intimated* that "space cannot be accomplished without time and velocity?" I gave it as my *impression* that F S is the *primive* formula for work; but have I objected to the expression F V T, when V is constant, or F $v\,dt$ when F is variable? In my article in the February number of the *Journal* for 1864, on p. 89 may be found the very equation which he has so freely used.

Is it necessary for Mr. Nystrom to resort to the elementary, although it may be a profitable exercise of "drawing chalk-lines upon a black-board," in order to convince him of what no one calls in question?

With regard to the term "mechanical power," or simple "power," which is represented by F v, I have raised no issue.

Students are familiar with the term, and all I wish to contend for is, that it is of the same *quality* as work, and that it is *the work* done in a unit of time under a constant velocity. In my last I expressed the desire that the term power might be restricted to this expression.

Let us see what results from Mr. Nystrom's stand-point. He says, p. 183, that "power is the differential of work." Do we not rightly infer from this that power is a part of work, an infinitesimal portion of it, and hence of the same kind or quality as work? Again, he says "F V T is the expression for work." Now, if T = one second, minute, or hour, do we not have F V = *the work* which is done in a unit of time? which is also the mechanical power. Then is not the mechanical power THE WORK done in a unit of time? Is not this "the difference between power and work?" Again, if V = 1 and T = 1, the expression becomes $F \times 1_{vel} \times 1_t$; which is THE WORK DONE in a unit of time and unit of space; may not the English horse-power be the unit of work, even if it be the unit of power? According to this analysis, is not the unit of power *a unit* of work?

If this view be correct, and it follows immediately from his equation, is it true that "the difference between foot-pounds of power and foot-pounds of work, is the same as the difference between square feet and cubic feet?" (See p. 188.)

On page 187, he says: "The substance of the so-called moment of inertia MR^2, is work when n is constant." How does this compare with what he has said before? Do we have the essentials of velocity and time in it?"

Mr. Nystrom has not criticised the article referred to in the No-

vember number of this *Journal* for 1862, more severely than I would. I used the word force in connexion with momentum and *vis-viva*, as it is popularly used. Mechanics say "the force of momentum," and mechanical writers say "living force." I do not defend the use of the terms, but, having accepted them, I see no reason for changing my views of the essential character of the *things* represented by them, call them what you may. A careful study of the article in the February number of 1864, would have made one or two of his criticisms unnecessary. I will pass over many important points, and modestly inquire, *where is his true reform?* I confess I do not see it, but trust I shall when he "brings it bodily out to sight."

For the Journal of the Franklin Institute.

On the Use of the Double Eye-piece in the Determination of the Personal Equation. By S. W. Robinson, C.E.

What is designed to be understood by the double eye-piece, in contradistinction to the binocular eye-piece is, that the former is designed for the use of a single eye of two observers, while the latter is intended for the two eyes of a single observer.

It was after I had conceived the idea, and constructed a double eye-piece, and had found it a very successful means of getting the personal equation, that I learned a similar contrivance had been used before. But my experiments upon it have been so successful, and the advantages of its use are so great, that I have thought them to be of sufficient interest for publication.

The principal advantage in its use consists in greatly diminishing computation for the reduction of the observations. By the usual method, with a reticule of fifteen threads, the first five only can be taken by the first observer, when he must give place to the second, who quickly gets into some posture and catches the last five. The thread intervals must be obtained by multiplying each of the *ten* equatorial intervals by secant of the star. These must be applied to the *ten* observations for only *five* results. By using the double eye-piece *fifteen* results are obtained from the same star passage over the same reticule of fifteen threads; the middle tally lost before being the best of the three in this case, while the only computing required is the simple subtraction of each of the fifteen signals by one observer from those of the other, respectively. Consequently the work of weeks is reduced to that of days, and also the results are believed to be much better, as it has already been found that the probable error of a single result is diminished about one-third. This is probably due in a great measure to the fact that the observers can retain their postures throughout the observation, and thereby evade the rapid transposition unavoidable in the use of the single eye-piece. In quite a series of observations taken by using the single eye-piece, for a personal equation which was found to be nearly zero, the person second in order, without reference to which, who necessarily took his position at the instrument hurriedly,

I have noticed, obtained almost invariably the smallest time for the transit of the star, with the illuminated end of the axis in either position. This shows a quickened action of the mind and nerves, causing the signal to be made by the depression of the key earlier than it otherwise would have been. If this disturbance is not equal in the two individuals, the resulting personal equation must be in error.

The supposed sympathy of mind with mind has been urged against the use of the double eye-piece, from the fact that the heads of the observers are in such proximity while observing. But I have been unable to detect the existence of any such influence in more than 1700 results which I have assisted in reducing. The resulting personal equation differed but ·005 from that obtained by using the single eye-piece. Two good results by any eye-piece are liable to a greater discrepancy.

The observations referred to above were recorded by the electro-chronographic process. In doing so it was found necessary to use two writing pens, either upon two chronographs or one. If upon one chronograph, two pen-carriages should be provided for it. I believe the chronography of every observatory should be thus equipped, then the observations of two observers at two different instruments, as the transit and equatorial, could be recorded at once, the two observers operating independently, and the two pens making their breaks from the action of the same break-circuit. I used two pen-carriages upon the same chronograph, taking one pen-carriage from another chronograph. They were so arranged that one pen commenced at the middle of the sheet while the other commenced at the edge. The chronographs were of the make of Wm. Bond & Son, of Boston. Each pen was connected with a battery, and each circuit provided with a key at the instrument. Both lines were independent, except at the clock, where both join the same wire and the same break-circuit. It was found that the batteries should be nearly equal, and like poles connected at the clock, so that the currents pass in the same direction over the break-circuit, otherwise the two currents become one without passing the break-circuit. But observing this, no difficulty was experienced in securing the independent action of the two pens from the keys of the observers, and their harmonious action from the single break-circuit. The keys were so constructed as to operate without emitting any audible sound to disturb the observers.

The double eye-piece could be so constructed as to be easily transformed into a binocular one. For example, the binocular described in a late number of *Silliman's Journal*, could be furnished with two straight tubes to receive the rays direct from the dividing triangular prism. These eye-tubes would then be separated by 120° of arc.

The eye-piece which I constructed had two reflectors of speculum metal in place of the triangular prism, so arranged as to bend the rays at right angles and throw them in opposite directions. The reflectors are inferior to the prism. I found the aberration most nearly corrected when the two plane convex lenses between the reflectors and image to be viewed were both placed with their convex surfaces toward the

reflectors. For these I used lenses of 1¼ inches focal length, and placed them about one inch apart, with the nearest about ⅜-inch from the reflectors. The eye-tubes or cross tube 7 inches in length, had at the extremities, Huygenian combinations of lenses of 1¼ and ¾-inches focal length. The magnifying power of the eye-piece is about twenty diameters. The field of view with this combination is not entirely uniform. It diminishes in brightness and clearness slightly from edge to edge in a direction perpendicular to the plane which divides the rays. This defect presents itself more strongely when the eye-piece is attached to a telescope, the aperture of the object-glass of which is small compared with its focal length, because the divergence of the rays from any point of the image is only equal to the convergence of the cone of rays transmitted through the object-glass, so that the rays from a point near the edge of the field do not spread sufficiently to allow an equal portion to fall upon the two reflectors. But examining an object separately with the eye-piece, this non-uniformity almost entirely disappears, because rays from any point of the object fall upon the entire surface of the objective, and become more generally diffused over the reflectors, and, consequently, more equally divided.

On the Invisible Radiation of the Electric Light. By JOHN TYNDALL, F. R. S.*

From the London Chemical News, No. 271.

Pending the preparation of my complete memoir, which may occupy me for some time to come, I would ask permission of the Royal Society to lay before the fellows a brief and partial summary of the results of my experiments on the invisible radiation of the electric light.

The distribution of heat in the spectrum of the electric light was examined by means of the linear thermo-electric pile, applied to the solar spectrum by Melloni, Franz, Müller, and others. The electric spectrum was formed by lenses and prisms of pure rock-salt, its width being equal to the length of the row of elements forming the pile. The latter, standing at right angles to the length of the spectrum, was caused to pass through its various colors in succession, and to search the spaces beyond the region of color in both directions.

As in the case of the solar spectrum, the heat was found to augment from the violet to the red, while the maximum heating effect was observed beyond the red, and at a distance from the red, in one direction, equal to that of the green of the spectrum in the other.

The augmentation of temperature beyond the red in the case of the electric light is sudden and enormous. Plotting from a datum line the thermal intensity of the various portions of the spectrum, the ordinates suddenly increase in length beyond the red, reach a maximum, and then fall somewhat more suddenly on the other side. When the ends of the ordinates are united, the curve beyond the red rises in a

* Abstract of paper read before the Royal Society.

steep and massive peak, which quite dwarfs the luminous portion of the spectrum.

The comparative height and steepness of this peak are much greater than those obtained by Professor Müller for the solar spectrum. Aqueous vapor acts powerfully upon the invisible rays, and, doubtless, the action of this substance in our atmosphere has toned down the eminence beyond the red in Professor Müller's diagram. A solar spectrum, produced beyond the limits of the atmosphere, would probably exhibit as steep a peak as that of the electric light.

In the experiments now to be referred to, the rays from the electric light were converged by a small concave mirror. The glass mirror silvered at the back, which usually accompanies the camera of Duboscq's electric lamp, was one of the first employed. It was brought so near the electric light as to cast an image of the coal-points five or six inches in advance of the light. A solution of iodine in bisulphide of carbon, contained in a rock-salt cell, was then placed in front of the lamp; the light was thereby cut off, but the focus of dark rays remained, and various effects of combustion and incandescence were obtained at the focus. A mirror four inches in diameter, and silvered in front, will enable an experimenter to obtain most, if not all, the results now to be mentioned. I also employ a mirror eight inches in diameter, and having a focal length of eight inches, with excellent effect.

It is not necessary to enclose the opaque solution in a rock-salt cell. The vessel intended for a solution of alum, which usually accompanies the lamp of Duboscq, and the sides of which are of glass, answers admirably. It is not, however, quite deep enough for the several tests to which I have subjected it, and, in crucial experiments, I employ a deeper vessel with rock-salt sides.

With the eight-inch mirror, just referred to, behind the electric light, the opaque solution in front, and the focus of invisible rays about six inches distant from the electric light, the following effects have been obtained:

1. Wood, painted black, when brought into the dark focus, emits copious volumes of smoke, and is soon kindled at the two spots on which the images of the two coal-points fall.

2. A piece of brown paper placed near the focus soon shows a burning surface, which spreads over a considerable space, the paper finally bursting into flame.

3. Black paper brought into the focus is immediately inflamed.

4. The wood of a hat-box, similarly placed, is rapidly burnt through, and usually bursts into flame.

5. The end of a cigar, placed at the dark focus, is instantly ignited.

6. Disks of charred paper placed in the focus are raised to brilliant incandescence, surfaces of considerable extent being brought to a vivid glow. Charcoal is also ignited.

7. A piece of charcoal, suspended in a receiver of oxygen, is ignited in the dark focus and caused to burn brilliantly, the rays after crossing the glass of the receiver being still sufficiently powerful to heat the coal up to incandescence.

8. A mixture of oxygen and hydrogen is exploded in the dark focus by the ignition of its envelope.

9. A piece of zinc foil, blackened on one side to diminish reflection, is pierced and inflamed. By gradually drawing the strip, once inflamed, across the focus, it may be kept blazing for a considerable length of time. This is a particularly beautiful experiment.

10. Magnesium wire, presented suitably to the focus, burns with its intensely luminous flame.

In all these cases the effect was due, in part, to chemical action; this, however, may be excluded.

11. A plate of any refractory metal, sufficiently thin, and with its reflective power suitably diminished, is raised to incandescence in the dark focus. Gold, silver, copper, aluminium, and platinum have been thus rendered incandescent.

12. Platenized platinum shows the effect best; in a thin leaf it may be rendered white-hot, and on it is depicted an incandescent image of the coal points. When the points are drawn apart, or caused to approach each other, their incandescent images conform to their motion.

The assemblage of phenomena here described, and others to be referred to in my completed memoirs, may, I think, be properly expressed by the term "calorescence." This word involves no hypothesis, and it harmonises well with the term fluorescence, now universally employed with reference to the more refrangible end of the spectrum.*

For the Journal of the Franklin Institute.

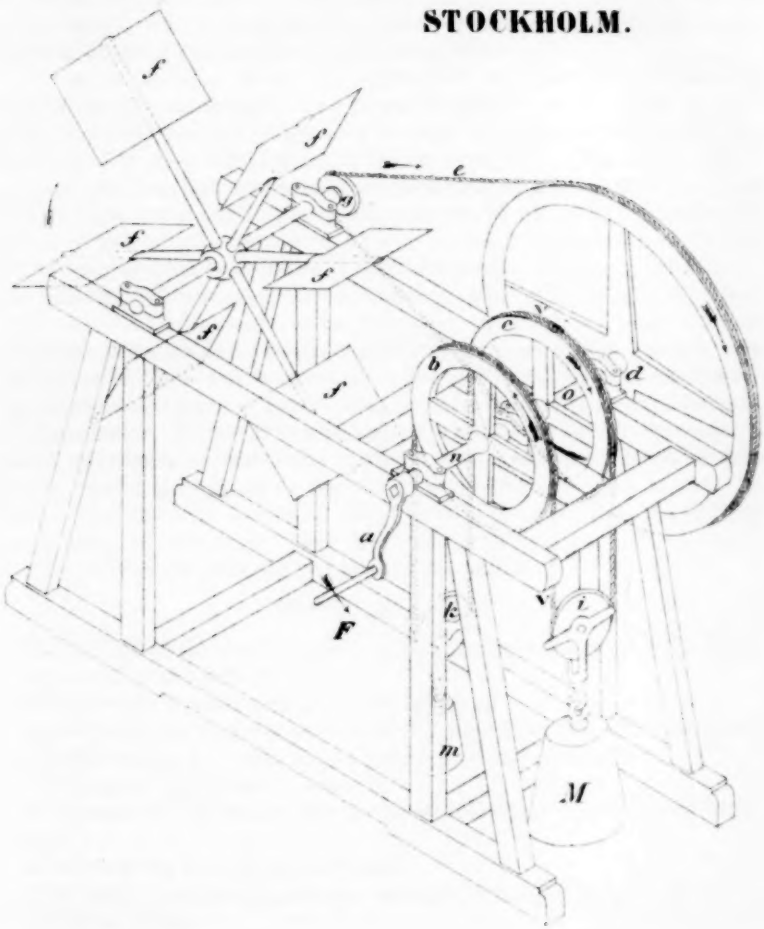
On the Dynamometer at the Royal Technological Institute, Stockholm.

By JOHN W. NYSTROM, Acting Chief Eng., U. S. N.

The proceedings of the stated monthly meeting of the Franklin Institute, in the April number of the *Journal*, contain a discussion on the dynamometer employed in the steam expansion experiments in New York. I have, on former occasions, noticed that this valuable instrument is very little known, that a description of the one at the Royal Technological Institute, Stockholm, will probably be read with interest. This dynamometer ought to be employed in every scientific institution, for we have yet no better means by which to imbue the student with the real substance of dynamics. Any student who has

* On December 5, last, I tried the passage of the rays from the electric lamp through a great number of different colored glasses. Incandescence was obtained through almost all of them; and, in one instance, the radiation passing through a blue glass, the thermograph of the coal points was of a pink color. A thick, black glass, obtained from Mr. Ludd, when held in front of the lamp, was found to be not perfectly opaque, still, the platinum could not be raised to incandescence at all when placed in the focus. Being called away from the Royal Institution early in the afternoon, I gave directions to my assistant, Mr Barret, to continue the experiments. He informs me that, on placing in the path of the rays a combination of two thin plates of black glass, one transmitting a whitish green, and the other a deep red, the light was entirely intercepted and feeble, though distinct incandescence was obtained at the focus. With radiation through the solution of iodine, the thermograph on this day rose to a white heat.

DYNAMOMETER
of the
Royal Tech. Institute
STOCKHOLM.



worked this instrument for a few hours, will probably not commit the error of saying that *work is independent of time, or that time* is included in power.

This dynamometer does not only teach the student the different properties of *force, power, and work*, but it enables him to conceive and compare, with great precision, real magnitudes of those quantities, which is of great importance in designing machinery.

The accompanying plate IV, represents an isometric perspective view of the dynamometer. The power is applied on the crank *a*, and communicated through the pulley *b*, rope V, pulley *c*, wheel *d*, rope *e*, rope-pulley *g*, and is consumed by the fans *f f f*. The shafts *n* and *o* are in one line, but not connected between the pulleys *b* and *c*. The endless rope V V is held tight in the grooves of the pulleys *b* and *c* by means of two weights *m* and M, as will be understood by the drawing. If the two weights were alike they could communicate no motion to the pulleys, but suppose $m = 10$ pounds, and $M = 20$ pounds, then there would be 10 pounds more weight on the sheave *i*, than on the sheave *k*, of which five pounds would pull on each pulley *b* and *c*. Let the radius of the crank *a* be equal to the radius of the pulleys, then it would require a force of five pounds to turn the crank in the direction of the arrow. If the crank is turned with an irregular velocity, it would only raise or lower the weights, but a constant force of five pounds would always act on the pulley *c* to communicate motion to the fans. The power in operation will be equal to the force multiplied by the velocity of the rope V, and the work accomplished will be equal to the power multiplied by the time of operation.

Notation of Letters.

R = radius of the crank in feet, which we have supposed to be equal to the radii of the pulleys *b* and *c*.

F = force in pounds acting on the crank *a*.

V = velocity in feet per second of the rope V, which, in the supposed case, will be equal to that of the velocity of the crank-pin.

t = time of operation in seconds.

P = power in dynamic effects, of which there are 550 per horse power.

W = work, in foot-pounds of work.

n = number of revolutions per minute of the pulley *c*.

Then we have

$$\text{the force } F = \tfrac{1}{2}(M - m), \text{ and velocity } V = \frac{2\pi R n}{60}.$$

$$\text{Power } P = F\,V, \text{ and work } W = F\,V\,t.$$

EXAMPLE.—Radius of the crank or pulleys, $R = 1{\cdot}25$ feet, making $n = 28$ turns per minute. $M = 80$, and $m = 20$ pounds. Required, the force $F = ?$, velocity $V = ?$, power $P = ?$, and how much work, $W = ?$, will be accomplished in one hour, or $t = 3600$ seconds.

Force $F = \tfrac{1}{2}(80 - 20) = 30$ pounds.

Velocity $v = \frac{2 \times 3{\cdot}14 \times 1{\cdot}25 \times 28}{60} = 3{\cdot}66$ feet per second.

Power $p = 30 \times 3{\cdot}66 = 109{\cdot}9$ effects.

Work $w = 109{\cdot}9 \times 3600 = 3956{\cdot}4$ foot-pounds.

The average power of a man working eight hours per day, is 55 effects, which will be an accomplished work of $w = 55 \times 8 \times 3600 = 1584000$ foot-pounds in a day's work.

In order to regulate the velocity to suit the power, the dynamometer has an arrangement by which to set the fans at any desired angle while in motion, which arrangement is not shown on the drawing. Students used to work the dynamometer in a spirit of emulation to outdo each other in power and work. Some could accomplish the greatest power, and work with less force and more velocity, whilst others preferred more force and less velocity.

Arrangements could easily be made to register on the dynamometer the force, velocity, power, and work, in the form of diagrams.

I do not know the origin or the inventor of this dynamometer, but, from the details of construction, would suppose it to be very old.

In the year 1850, I made a great many experiments with different screw propellers, when I employed a dynamometer of this description, made by Thomas Mason, of Philadelphia, which gave great satisfaction, and I have always considered it the best form of dynamometer where it can be conveniently applied. In regard to the mechanism for receiving the work in the New York expansion experiments, it appears to me that a paddle-wheel, or propeller, wholly immersed and revolving in water, would be better than the numerous fans working in air. Water would form a more substantial receiver of work, and, at the same time, would combine the interesting experiment of Mr. Joule, to regenerate and realize the work in the form of heat in the water.

For the Journal of the Franklin Institute.

Particulars of Iron Steamships.

Caledonia.—Hull built and machinery constructed by Messrs. Tod & McGregor, Glasgow, Scotland. Route of service, New York to Glasgow. Owners, Anchor Steamship Company.

Hull.—Length on deck, 261 feet 6 inches. Breadth of beam, 33 feet 2 inches. Depth of hold, 21 feet 6 inches. Depth to spar-deck, 28 feet 9 inches. Number of decks, 3. Draft at load-line, 19 feet. Frame of wrought iron plates, $\frac{7}{8}$ to $\frac{3}{4}$ of an inch in thickness, and fastened with rivets $\frac{3}{4}$-inch in diameter, and $2\frac{3}{4}$ inches apart. Floors, shape, Z L, molded, 5 inches, sided, $\frac{3}{8}$-inch, apart at centres, 18 inches. Beam ties on each deck. Bulkheads, 5. Rig, barque. Tonnage, 1393 tons, O. M.

Engines.—Vertical direct. Number of cylinders, 2. Diameter of cylinders, 42 inches. Length of stroke of piston, 3 feet.

Boilers.—Two, tubular. Have water bottoms.

Propeller.—Diameter, 14 feet. Number of blades, 2. Material, cast iron.

REMARKS.—A first-class vessel. Built and fitted as an ocean passenger steamship should be.

Atalanta.—Hull built and machinery constructed by Messrs. Smith & Rogers, Glasgow, Scotland. Route of service, New York to London. Owners, London and New York Steamship Company.

Hull.—Length on deck, 338 feet. Breadth of beam, 34 feet 6 inches. Depth of hold, 13 feet 9 inches. Depth to spar-deck, 22 feet 2 inches. Number of decks, 2. Draft at load-line, 21 feet. Frame of wrought iron plates, 1 inch to ⅜ of an inch in thickness, and fastened with rivets ¾-inch in diameter, and 4 and 4¼ inches apart. Floors, shape, Z L, molded, 6 inches, sided, ⅝-inch, apart at centres, 18 inches. Beam ties on each deck. Bulkheads, 6. Rig, four-masted barque. Tonnage, 1988 tons, O. M.

Engines.—Steeple. Number of cylinders, 2. Diameter of cylinders, 60 inches. Length of stroke of piston, 4 feet.

Boilers.—Two, tubular. Have water bottoms.

Propeller.—Diameter, 18 feet. Number of blades, 2. Material, cast iron.

REMARKS.—A well built and well fitted vessel, complete in her equipment, and having large passenger accommodations and cargo-carrying capacity.

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Washington.—Hull built by Messrs Scott & Co., Greenoch. Machinery constructed by Greenoch Foundry Company. Route of service, New York to Havre. Commander, Captain A. Duchesne. Owners, Compagnie General Transatlantique.

Hull.—Length on deck, 350 feet. Breadth of beam, 45 feet. Depth of hold, 22 feet 8 inches. Depth to spar-deck, 33 feet. Number of decks, 4. Draft at load-line, 17 feet 6 inches. Frame of wrought iron plates, 1 inch to ⅜-inch in thickness, and fastened with rivets ¾-inch in diameter, and 3 inches apart. Floors, shape, Z Z, molded, 6½ inches, sided, ¾-inch, apart at centres, 20 inches. Wrought iron plate stringers on two decks. Bulkheads, 6. Rig, brig. Tonnage, 3443 tons, O. M.

Engines.—Side lever. Number of cylinders, 2. Diameter of cylinders, 94½ inches. Length of stroke of piston, 8 feet 8 inches. Nominal horse power, 850. The levers are of malleable iron, each 24 feet long, 7 feet wide at centre, 2½ inches thick, and weighing 15 tons.

Boilers.—Four, tubular. Have water bottoms. Length of boilers, 22 feet. Breadth, 12 feet. Height, 14 feet. Number of tubes in each boiler, 284; brass. Weight of each, about 60 tons. These boilers are encased in malleable iron plates, 2 inches apart from the boilers, and so constructed that any portion can be removed without taking down the whole casing.

Water-wheels.—Diameter, 37 feet 6 inches. Material, iron.

REMARKS.—This magnificent steamship deserves more than a passing notice. It is built in the most approved manner, and reflects great credit upon her builders, who are universally known and accepted as one of the most successful ship-building firms in Europe. This vessel has accommodations for three hundred and fifty first-class passengers, and capacity for 1000 tons of freight, besides being able to store 1500 tons of coal in her bunkers. Her interior is beautifully decorated and sumptuously fitted up. The steamships *Lafayette* and *Europe*, running upon the same route, are sister ships to the *Washington*, and were constructed by the same builders, whilst the *France* and *Napoleon III*, of similar dimensions, will soon be ready to take their respective positions in the line. The two last vessels are being constructed by Messrs. Scott & Co., at St. Nazaire, France.

Westminster.—Hull built and machinery constructed by Messrs. Fossick & Hackworth, England. Route of service, New York to Liverpool. Owners, National Steam Navigation Company.

Hull.—Length on deck, 271 feet. Breadth of beam, 38 feet. Depth of hold, 29 feet 9 inches. Number of decks, 3. Draft at load-line, 18 feet 6 inches. Frame of wrought iron plates, $\frac{7}{8}$ to $\frac{3}{4}$-inch in thickness, and fastened with rivets $\frac{3}{4}$-inch in diameter, and 3 inches apart. Floors, shape, Z L, molded, 6 inches, sided, $\frac{5}{8}$-inch, apart at centres, 18 inches. Beam ties on two decks. Bulkheads, 5. Rig, barque. Tonnage, 1897 tons, O. M.

Engines.—Vertical direct. Number of cylinders, 2. Diameter of cylinders, 60 inches. Length of stroke of piston, 2 feet 9 inches.

Boilers.—Four, tubular. Have water bottoms.

Propeller.—Diameter, 16 feet. Number of blades, 3. Material, cast iron.

REMARKS.—A first-class, superior built steamship, having great strength, comfort, and safety combined in her construction. She is fitted with all that is requisite in a vessel of her character, and that this is appreciated is evident from the hundreds of passengers she regularly lands in New York.

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*Iowa.**—Hull built by Messrs. Malcomson Bros., Waterford. Machinery constructed by Messrs. Smith & Rogers, Glasgow. Route of service, New York to London. Owners, London and New York Steamship Company.

Hull.—Length on deck, 338 feet. Breadth of beam, 34 feet 6 inches. Depth of hold, 13 feet 9 inches. Depth to spar-deck, 22 feet 2 inches. Number of decks, 2. Draft at load-line, 21 feet. Frame of wrought iron plates, 1 inch to $\frac{3}{4}$-inch thick, and fastened with rivets $\frac{3}{4}$-inch in diameter, and 4 and 4$\frac{1}{4}$ inches apart. Floors, shape, Z L, molded 6 inches, sided, $\frac{5}{8}$-inch, apart at centres, 18 inches. Beam ties on each deck. Bulkheads, 6. Rig, four-masted barque. Tonnage, 1988 tons, O. M.

Engines.—Steeple. Number of cylinders, 2. Diameter of cylinders, 60 inches. Length of stroke of piston, 4 feet.

Boilers.—Two, tubular. Have water bottoms.

Propeller.—Diameter, 18 feet. Number of blades, 2. Material, cast iron.

REMARKS.—This vessel is well fitted, and is a first-class steamship.

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City of Boston.—Hull built and machinery constructed by Messrs. Tod & McGregor, Glasgow, Scotland. Route of service, New York to Liverpool. Commander, Captain James Kennedy. Owners, Philadelphia, New York and Liverpool Steamship Company.

Hull.—Length on deck, 305 feet. Breadth of beam, 39 feet. Depth of hold, 27 feet 6 inches. Number of decks, 3. Draft of water, 20 feet. Frame of wrought iron plates, 1 inch to $\frac{3}{4}$-inch thick, and fastened with rivets 1 inch and 1$\frac{1}{4}$ inches in diameter, and 2$\frac{1}{2}$ and 3 inches apart. Floors, Shape, Z Z, molded, 6 inches sided, $\frac{1}{2}$-inch, apart at centres, 21 inches. Beam ties on all decks. Bulkheads, 5. Rig, ship. Tonnage, 2254 tons, O. M.

Engines.—Trunk. Number of Cylinders, 2. Diameter of cylinders, 69 inches. Length of stroke of piston, 3 feet.

Boilers.—Four, tubular. Have water bottoms.

Propeller.—Diameter, 18 feet. Number of blades 3. Pitch, 24 feet. Material cast iron.

REMARKS.—For strength, speed, and beauty, this vessel cannot be

* This vessel recently ran upon a rock near Cherbourg, and was sunk.

excelled. She is constructed in the very best manner, and will, undoubtedly, sustain the high fame of the line for which she was built. The deck is made of iron plates of the best quality, manufactured by the Mersey Steel and Iron Company, and upon these plates is laid the ordinary timber deck. This line now consists of thirteen of the finest screw steamships afloat, and there are two more, the *City of Paris* and the *City of Durham*, now being built. Originally the line consisted of one or two ships only, and its rapid rise may be attributed to the tact and talent of its officers. The company have achieved a great success, and they deserve it, because they have worked for it.

E. M. B.

For the Journal of the Franklin Institute.

Speed of Ships

The clipper ship *Sea Serpent*, Captain Winsor, arrived at San Francisco on the 16th of March, 1865, having made the run from New York in 102 days, which is the second shortest passage made during the past four years. Within the above period, the best runs have been those of the *Panama* in 100 days, the *David Crockett* in 107 days, and the *Sea Serpent* in 102 days, all of them belonging to Messrs. Sutton & Co.'s line, New York.

The Panama Railroad Company's barque *Xantho*, Captain Conway, left New York March 3d, 1865, arrived at Aspinwall in 12 days, left there March 24th, arriving at New York April 5th, in 12 days, making the voyage in 33 days, being the shortest on record.

The barque *Albertina*, Captain Richard Olmstead, formerly in the Havana trade, has made the voyage from Port Elizabeth, Algoa Bay, to New York in the remarkable time of 45 days.

The barque *Imaum*, of Boston, Captain Luther Hurd, has made the voyage from Boston to Marseilles, thence to Messina, discharging and taking in full cargo at each port, and returning to Boston in 100 days.

E. M. B.

The Value of Stone Under Fire.

From the London Builder, No. 1156.

The superintendent of the London Fire-engine Establishment, in his last report, to which we have already alluded, comments on the errors and omissions of the Building Act. In the course of these observations he quotes:

"Sec. 22. The lobbies, stairs, &c., of a certain class of buildings must be made of 'stone or other fire-proof material;'" and says: "This enactment involves an error, inasmuch as stone is in no sense fire-proof; on the contrary, it yields to fire sooner than almost any other building material, and much more rapidly than wood. It is true that it does not, like wood, add fuel to the fire, but it does worse, as its known tendency to split off from the walls, and fall down altogether,

prevents the firemen from availing themselves of the best positions for their work, which they can almost always occupy where there are wooden staircases. For a staircase on the outside of a building, stone may be safely used, but its brittleness, when exposed to different degrees of heat in different parts, makes it an unsafe material for inside staircases or lobbies, which are liable in case of fire to undergo a sudden expansion in the tread or exposed part, while the support or part resting inside the wall is scarcely raised in temperature; or, if they escape this danger, and get hot so slowly as not to break, the water from the engines, or even in some cases the draught of cold air caused by opening a door or window, is quite sufficient to contract and split the stone. In both cases the fracture occurs in the same place, close to the wall."

The reporter then goes on to say: "No staircase can be really fire-proof, unless constructed either of fire bricks laid in fire cement, which would be both costly and cumbrous, or of wrought iron, which for appearance, comfort, or convenience, might be covered with slabs of slate, stone, or wood. In this latter case the real strength would consist, not in the stone or other covering, but in the wrought iron framing; and such stairs, particularly if protected by plaster, which could be easily done, might safely be relied on in all ordinary fires, as the heat near a staircase being tempered with the cold draught from the outside is rarely sufficient to weaken wrought iron, which only fuses at about 3000° Fahrenheit, and retains a considerable portion of its strength almost to the melting point. That paragraph which asserts that stone is a fire-proof material suited for lobbies, stairs, &c., has done incalculable injury, as may be observed at the scene of any fire in a building so constructed, particularly if there have been both wooden and stone stairs, in which case it almost invariably happens that some part of the wooden stairs is saved, while the stone is completely destroyed, and generally discovered afterwards among the ruins in the basement. It seems, therefore, wrong to continue any longer a compulsory law based on a grave error, and certain always to do, as it has already done, most serious injury to life and property. The only way in which a stone staircase can be saved in a building on fire, is to flood it with water at an early stage, and this must always occupy the attention of the firemen at the very time when their efforts would otherwise be exerted in a totally different direction."

Of course the experience of the superintendent in this direction has been considerable, but we should be glad, nevertheless, to have some additional evidence as to the behavior of all stone staircases under fire.

The Hydrostatic Girder.

From the London Mechanics' Magazine, April, 1865.

The hydrostatic girder is the name applied to a new invention, by the use of which the pressure resulting from any weight which it may be found necessary to place upon a girder, is equally distributed over the whole surface. This distribution of pressure tells best in a large

bridge or viaduct, as by its application in such cases the whole of the structure may be made of lighter material, at a consequently reduced cost, without any diminution of safety. The girder consists essentially of two hollow girders, one of which just fits into the other, allowing a small space around it to be filled with water. The weight which the whole girder is required to support is placed upon the smaller or floating girder. In ordinary girder bridges the weight of a passing train has to be borne by every inch of the girder in succession; and when the supports are far between this necessitates a great increase in the strength of the structure, with its consequent increase of expenditure.

The principal advantages in the hydrostatic girder arise from making the floating girder continuous, or without any other support than the water between it and the larger girder throughout the whole length. From well-known hydrostatic laws it is evident that, wherever the weight may be placed upon the floating girder, (which weight must, of course, be proportional to the amount of water displaced by the floating girder,) the pressure arising from such weight will be distributed over the whole of the lower girder. Another advantage of the new construction is the absence of that vibration caused by the passage of a heavy train which is so injurious to cast iron structures. It may be observed that the principle of the hydrostatic girder is not limited to bridge building. It is well known that the repairs to the permanent way, which form so large an item in railway expenses, are rendered principally necessary by the transit of those heavily-laden springless trucks of coal, which operate upon every inequality of the line in their passage, with all the injurious effects of a steam hammer. By a simple application of the hydrostatic principle a cheap and yet efficacious spring might be provided, obviating in a great measure the damages caused to the permanent way.—*Building News.*

Steel Locomotives.

From the London Mechanics' Magazine, April, 1865.

The Maryport and Carlisle Company have for some time past employed steel to a great extent in substitution for ordinary iron for the working parts of locomotives, and, as we are informed, with the most satisfactory results. The traffic on the line is principally coal and mineral. It has been found that with the ordinary iron tires on the engine wheels, the distance run was not more than 90,000 miles—in many cases not more than 60,000 miles—and the wheels require to be taken from under the engine for every 20,000 or 30,000 miles run, for repairs and "turning up." In the case of the steel tires, however, the wheels will run 100,000 miles before they require "turning up" or repairing. The *Railway News* states that the result of a very careful examination of the effects of wear leads to the opinion that these wheels will run from 350,000 to 500,000 miles, or equal to some twelve or fifteen years work of a daily average of about one hundred miles. The difference of cost as between the two metals is not great; in the one case it ranges from £40 to £45 per ton, while the steel is about £55,

the cost of labor in placing the tires on the wheels being nearly the same in each case. The company have a number of boilers, axles, cranks, and eccentrics, made of steel, in constant use on the line, and they have given the greatest satisfaction. These have not, however, been sufficiently long in operation to enable a comparison to be drawn between them and the ordinary portions of the locomotives; but there is reason to believe that the saving in point of wear will be equal to that effected by the substitution of steel for ordinary iron tires. The ordinary eccentrics are expensive to keep up, but those which are made of hardened steel do not require any looking after for ten years, not even to the slacking of a bolt, so far as regards repairs. The experience obtained on this, and we believe upon some other railways, points to a very important mode of saving in one of the largest items of cost in the working expense of railways. The subject will, we have no doubt, receive careful consideration from the managers of railways.

Singular Boiler Explosion.

From the London Mechanics' Magazine, April, 1865.

In the last report of Mr. L. E. Fletcher, Chief Engineer of the Manchester Boiler Association, an account is given of an explosion which occurred at an iron works, on the 9th February last, to a boiler which was not under the inspection of the Association. This explosion was of a very peculiar character, inasmuch as a plate, having a superficial area of about five square feet, was torn out of the side of the boiler through the solid metal, and shot away by the force of the steam, while the boiler remained in its place unmoved, and in other respects intact. By the flight of this piece of plate, as well as by that of a portion of the brickwork by which the boiler was surrounded, the roofing of part of the works was carried away, and two men were seriously injured. A few days after the explosion Mr. Fletcher visited the works, but found that repairs to the boiler had been commenced, and rent plates cut out, so that he had not so favorable an opportunity of conducting his investigations as could be desired. An engineer, however, who was previously familiar with the boiler and all its working conditions, and who examined it immediately after the explosion occurred, furnished full particulars and sketches. The boiler was one of six, which, though situated at different parts of the works, were yet connected together, both by the steam and feed-pipes. It was of the externally-fired upright furnace class, so commonly employed at iron works, and was constructed to receive the waste heat from three puddling furnaces. One of these had, however, been exchanged for a fire-grate of large dimensions, so that the boiler was heated by the flames passing off from two puddling furnaces and from one fire-grate. The height of the boiler was 24 feet, while its diameter was 7 feet 9 inches in the external shell, 4 feet in the central descending flue, and 2 feet in the three internal branch-tubes which radiated from it, the plates being $\frac{7}{16}$-inch in thickness, and the usual working pressure of steam about 35 lbs. per square inch.

The shape of the piece of plate blown out of the side of the boiler was an irregular parallelogram, measuring about 3 feet 6 inches vertically, and 1 foot 10 inches horizontally, at the widest part. It was intersected about mid-height horizontally by a ring seam of rivet, which encircled the boiler, and at this line the ejected plate tore asunder into two pieces of somewhat equal size, while the other rents round its circumference were through the solid metal. The hole made in the side of the boiler was situated, as nearly as may be, on a level with the inlets to the central descending flue, and a little to the right hand to the one fed from the fire-grate, which had been substituted for the puddling furnace, so that it will be seen that the rupture took place near to, but somewhat below, low water mark. The cause of this remarkable rent did not appear to have been brittleness of the plates, since they withstood repeated and severe blows with a heavy hammer, neither does the local character of the injury allow of its being attributed to overpressure of steam, but there seems little reason to doubt that the rent was caused by the plates being overheated, since it appeared upon examination that the sides of the boiler had bulged four inches outward, in the first place, and then rent down the centre of this bulge in a vertical direction, folding back on one side very much like the leaf of a book, or a door on its hinges, the edges of the plates at the primary rent—which was shown to be such by the direction of the flight of the parts—being drawn out, as they only could have been when the metal was hot, while the fracture at the hinge was that of colder metal. This overheating has been attributed to shortness of water, but the man in attendance stated that the float indicated an ample supply—there being a depth of 3 feet 6 inches over the crown of the central descending flue-tube—and that the feed was not only going into the boiler when the explosion occurred, but had being doing so for some time previously; while it may be added that there was a feed back-pressure valve fixed to the boiler to prevent the water from returning through the feed-pipe, and that the float is reported to have been in working order.

Shortness of water is by no means essential to the overheating of the plates in a boiler when they are played upon by an intense fire, and the flames allowed to impinge locally, especially if the water be not good; and many cases have been met with in which, under these circumstances, plates have become overheated, although there has been plenty of water in the boiler at the time. In the present instance, the flames from the large fire-grate—which was fed with coal instead of slack, in order to raise more steam—played directly upon the vertical side of the boiler, and just at the part where the rupture occurred, while the water contained a good deal of loose sludgy deposit, and was found frequently to foam up, and cause the boiler to prime. In vertical heating surfaces, the steam is apt to cling to the plates, and to creep between them and the water. This, in the upright single flue internally-fired furnace boiler, in frequent use at iron works, has been found to have such an injurious effect upon the flue-tube, and lead to so many collapses, that this description of boiler has in many cases

been discarded. There is, therefore, every probability that the overheating was due, not to a deficiency in the supply of the water, but to its being driven away from the plates by the rapid ebullition of steam within the boiler, caused by furious firing, and the too local impingement of the flames upon a vertical surface combined with the use of sludgy water. This view is corroborated by the fact, that when overheating occurs in consequence of ordinary shortness of water, the plates are injured in a line parallel to its surface, whereas in this case they both bulged and rent in a line at right angles to it, and for a length of as much as 3 feet 6 inches. So that the statement of the fireman may after all be correct, that there was plenty of water in the boiler at the time of the explosion, while its occurrence is only another illustration of the dangerous character of these externally-fired upright furnace boilers.

The Injurious Action of Alkalies on Cotton Fibre. By Messrs. Heinrich Caro and William Dancer.

From Newton's London Journal of Arts, May, 1865.

A remarkable instance of the deleterious action of alkali on cotton fibre lately came under our notice, when examining some indigo prints which had been stiffened or finished with silicate of soda, and kept in bales during about two years. The strength of the fibre of the greater part of these goods had decreased to about one-third of the strength of some pieces which had been packed in the same bales, and which differed in no other respect from the others, except in their having been finished with starch. We therefore surmised that silicate of soda had been the primary cause of the deterioration of the goods. Further observations convinced us, however, that the injury was due to the long continued action of free or carbonated alkali upon the cotton fibre.

Some of the sound pieces (which, as before mentioned, had been finished with starch), had been packed between the silicated goods, and had abstracted soda from them which had penetrated from the places of contact into the interior of the pieces to a considerable depth. In the same ratio in which the pieces had taken up soda, it was found that they had diminished in strength. On the other hand, it was found that in such places of contact, the silicate of soda of the silicated goods had suffered a partial decomposition, extending to the depth of four or five layers of the pieces. The silicate of soda in the middle of the pieces contained from 70 to 74 per cent. of silicic acid, combined with from 30 to 26 per cent. of soda; whilst the analysis of the silicate of soda contained in the contact layers, showed that from one-third to two-thirds of its soda had been extracted. This loss of soda was accompanied by a change of strength of the cloth which appeared to bear some proportion to it, the layers or folds of the cloth *decreasing* in strength as they were removed from contact with the starched goods, until the silicate of soda attained the same composition as that found in the most rotten parts of the piece, this generally taking place about the fourth or fifth layer or fold of the piece, as before stated.

The following table shows the change in strength produced by this decomposition of the silicate of soda:

	Finished with Starch.		Finished with Silicate of Soda.					
	Middle.	Contact Layer.	Contact Layer.	2d.	3d.	4th	5th.	Middle.
Strength.	100	81	89	68	62	54	48	35

The silicate of soda had evidently been decomposed with the formation of free alkali and an acid silicate, which appears to have very little action on the cotton fibre.

In some places the decomposition had gone further, and free silicic acid had separated out in the form of a white powder upon the surface of the cloth. The same decomposition, accompanied by the same changes in the strength of the cloth, was observed upon all pieces which had been in contact with the paper used for wrapping the bales. In this instance the paper had absorbed the liberated soda, and the cloth in contact with it had almost entirely retained its original strength.

The white portions of the patterns were in a further advanced state of decay than the blue ones, in most instances retaining only 10 per cent. of their original strength. In the goods finished with starch only, the whites were equally as strong as the blues. In the goods finished with silicate of soda, the whites were almost as strong as the blues in all places where the before-mentioned decomposition of the silicate of soda had been accompanied by an abstraction of soda; but in the interior of the goods, where the silicate of soda had retained its original composition, the strength of the whites had decreased to about one-third of that of the blues. It was therefore evident that this excessive decay of the whites was due to some cause which had assisted the action of the alkali upon them; and we believe to have found an explanation of this in the action of the silicate of soda upon the sulphate of lead contained in them to the amount of about 10 per cent. of the mineral ash.

Sulphate of lead has been an ingredient of the resist paste printed upon the places intended to remain white, and by the subsequent action of lime and sulphuric acid it has become fixed in the fibre. We have noticed that sulphate of lead decomposes solutions of silicate of soda very rapidly, with formation of sulphate of soda, free silicic acid, and silicate of lead.

These changes give rise to the production of a crystallizable and strongly efflorescent salt, and to increase in bulk; and we think that the mechanical effect produced by the crystallization of the sulphate of soda formed may have caused a further and final integration of the fibre already weakened by the action of the alkali. Under the microscope the fibre of the white portions of the pattern presented the appearance of *cylindrical* tubes, partially covered with minute crystals

(soluble in water); in some places these tubes appeared to be split longitudinally.

On the Supposed Nature of Air prior to the Discovery of Oxygen.

By GEORGE F. RODWELL, F.C.S.

From the London Chemical News, No. 269.

Continued from page 340.

10. *Robert Hooke.*—Robert Hooke was born in 1635. In 1653 he went to Oxford, where he made the acquaintance of Boyle, who was so struck with his aptitude for devising experiments and constructing apparatus that he engaged him as his assistant; and these two greatest experimental philosophers of the age immediately succeeding that of Bacon worked together for several years on numerous branches of science. Hooke was a man of great erudition—his writings relate to all the physical sciences known at the period; he excelled greatly as a mechanician, and his inventions are said to number more than a hundred. Among others we may mention the circular pendulum, the wheel barometer, and instruments to graduate thermometers, to measure time with exactness, to determine the refractive power of liquids, to grind optical glasses, and to show the number of vibrations of a string requisite to produce a certain note. Moreover, he greatly improved the microscope and telescope.

Hooke's first scientific treatise* was published in 1661; in it he endeavored to explain the cause of some effects observed by Boyle, as to the rise of water in tubes of small diameter. It was the ingenuity of this treatise which first brought Hooke before the notice of the recently formed Royal Society, and it was immediately proposed that he should be requested to act as curator to the Society. To this office he was elected on November 12, 1662, and it was ordered that he should be required to show "three or four considerable experiments" whenever the Society met; a vote of thanks was passed to Boyle for dispensing with the services of so valuable an assistant.

At the following meeting, (November 19,) Hooke showed some experiments to prove the weight of air. A globe of glass, the interior of which communicated with the air by a tube of small diameter, was heated to bright redness, and sealed before the blow-pipe; when cool it was placed in the scale of a balance, and counterpoised by weights of the opposite scale; on now breaking off the end of the tube so as to admit air to the globe, the latter preponderated. Into a similar globe a small quantity of water was introduced, which was completely evaporated, the globe heated to redness, sealed before the blow-pipe, and counterpoised as in the previous experiment; on admitting air the globe preponderated, and the weight of air which had entered was shown by

* This treatise extends over fifty small pages. It is entitled "An attempt for the explication of the phenomena observable in an experiment published by the Hon. Robert Boyle, in the 35th experiment of his epistolical discourse touching the air. In conformation of a former conjecture made by R. H." London: 1661. Hooke re-published this treatise four years later in the "Micrographia." (Obs. 6, "Of small glass canes.")

placing weights on the opposite scale, until equilibrium was restored. On December 3 he varied the experiment: two small glass globes, one and a half inch in diameter, were sealed at the ordinary temperature, and suspended from one end of the beam of a balance in such a way that the globes preponderated; the balance was introduced into an air-tight vessel into which air was condensed, the globe now ceased to preponderate; on allowing the condensed air to escape from the vessel, the globes returned to their former position.

In 1664 Hooke presented the manuscript of his "Micrographia"* to the Royal Society, and the President, by an order dated Novem er 23, 1664, ordered it immediately to be printed. The "Micrograph a" is chiefly devoted to the description of microscopic bodies, but it a so contains a great amount of experimental observation in various branch s of natural philosophy, particularly in optics; it is in every way wort y to be among the first works published by a Society instituted for the purpose of investigating natural phenomena by experiment.

In the preface, Hooke describes the wheel barometer which he had recently devised for showing minute changes in the pressure of the air; the circle was divided into 200 parts, but there were no indications upon it to show what kind of weather might be expected when the index stood at a certain point. From a number of observations, Hooke found that the mercury invariably fell before rainy weather, and that it rose before dry weather and during the prevalence of an easterly wind.

The air, according to Hooke, is a mixture of terrestrial and aqueous particles, "dissolved and agitated by the ether;" and just in the same way that a few grains of salt may be diffused through a large quantity of water, so, he says, a small quantity of water may expand and diffuse itself through a large space; on the other hand, as a small quantity of water is able to dissolve a quantity of salt which could diffuse itself through a large quantity of water, so a quantity of air which could expand and diffuse itself through a large space may be contained within a small compass.

In the 7th observation of the "Micrographia," Hooke describes the spirit thermometer which he introduced into England, and which had been invented a few years previously by one of the members of the Accademia del Cimento. Hooke constructed thermometers of such delicacy that, although the stem was four feet long, the spirit rose nearly to the top of the tube in summer, and sunk nearly to the bulb in winter. The freezing point of water was the zero of the scale.

Observation 9 is entitled, "Of the fiery sparks struck off from a flint or steel." It was anciently believed that, when flint and steel are struck together, sparks are produced by the attrition of the air. Lucretius supposed that lightening is produced by the collision of two clouds, in the same way that sparks are produced by the collision of flint and steel. Bacon† mentions that the sparks descend, and when

* "Micrographia, or some Physiological Descriptions of Minute Bodies made by Magnifying Glasses." London: 1665.

† "Novum Organum," Book 2, Aph. 12.

extinguished are found to be a kind of "dark ash." He affirms, moreover, that they are in reality particles struck off from the flint or steel, raised to ignition by the violence of the friction. Des Cartes endeavored to explain the production of the sparks according to his three-element theory,* and in so doing gave a most obscure and unphilosophical explanation; this induced Hooke to examine the phenomenon for himself. Accordingly he collected a number of the particles which had appeared as sparks of fire when first struck off from the steel, and examined them under the microscope; they were then seen to be spheres with a metallic lustre so bright that bodies could be seen reflected in them. The sparks are, therefore, he contends, minute particles of steel which, by the violence of the friction, are raised to a red heat, and then take fire and burn, because "there seems to be a very combustible sulphureous body in iron or steel, which the air very readily preys upon, as soon as the body is a little violently heated."

To be Continued.

New Electro-magnet.

M. Du Moncel presented to the French Academy of Sciences at their meetings on the 9th and 16th of January last, the results of his examination into a very curious and useful discovery made by M. Carlier, a machinist of Paris. Heretofore in constructing an electro-magnet it has been considered indispensable to devote the greatest attention to the insulation of the different turns of the wire from each other by wrapping with silk or cotton, or carefully varnishing. It occurred to M. Carlier to try the effect of wrapping with a simple uncovered wire, and, greatly to the astonishment of electricians, it is found that under certain conditions, the attractive force of the magnet is greatly increased, while its extra or inductive current becomes

* The basis of the physical philosophy of Des Cartes is the hypothesis that all matter consisted originally of square particles, which at the creation were endowed with two motions—the one causing each particle to revolve separately, the other causing groups of particles to revolve around a common centre. The particles during their revolution gradually had their angles worn down by the frequent friction, and thus three elements were produced. The first element, of which the sun, stars, and fire are composed, is the dust produced by the abrasion of the angles; the second, which constitutes the atmosphere, and all the matter between the earth and the stars, consists of the spheres which remain when the angles of the original square particles have been worn perfectly smooth; and the third, of which the earth and all terrestrial bodies are composed, consists of the particles which are neither spherical nor square, but which are partly worn smooth and partly have their angles remaining.

The following is the explanation which Des Cartes gives of the production of sparks by the collision of flint and steel:—" . . . consideremus primo varios modos quibus ignis generatur. . . . Nihil usitatius est, quam ut ex silicibus ignis excutiatur; hoc que ex eo fieri existimo, quod silices sint satis duri et rigidi, simulque satis friabiles, ex hoc enim quod sint duri et rigidi, si percutiantur ab aliquo corpore etiam duro, spatia quæ multus eorum particulas interjacent, et a globulis secundi elementi solent occupari, solito fiunt angustiora, et ideo isti globuli exsilire coacti, nihil præter solam materiam primi elementi circa i las relinquunt deinde ex eo quod sint friabiles, simul ac istæ silicum particulæ non amplius ictu premuntur, ab invicem dissiliunt, sicque matariæ primi elementi, quæ sola circa ipsas reperitur, innatantes ignem componunt."—" Principia," Pars quarta, par 84.

scarcely sensible. Thus an electro-magnet, having an iron core 4½ centimetres long and 7 millimetres in diameter, carrying a single row of spires of fine wire 0·277 mm. diameter, in all 103 spires, supported under the influence of two small Bunsen couples, 3·9 kil., while the same core wrapped with a covered wire, supported only 2·4 kil. It is true that but 77 turns of the covered line could be put upon the core.

The effects at a distance was still more favorable to the uncovered wire.

It is to be observed that if more than one thickness of wire coil is put over the core, the different thicknesses must be carefully insulated from each other by paper. The wire, too, must be insulated from the core by paper, silk, or wood.

After a very careful study of the phenomena, showing that in order to produce these effects, the uncovered wire must be acted on by a battery arranged collaterally, or for quantity, and that with a battery arranged consecutively, (or for intensity,) the covered wire resumes its superiority, M. Du Moncel suggests that the phenomena depend upon a great number of minute currents, which are drawn from the main current at the points of contact of the turns of the wire, the main current following the wire, however, because in that direction the resistance is much the least. For this same reason these minute currents move around the wire instead of across it, and thus add considerably to the influence on the core, while they entirely prevent the induction effect by which is produced the annoying spark and counter-current at making and breaking connexion. He finishes his essay as follows:

"It results from all these experiments that quantity currents are particularly suited to electro-magnets with uncovered wire, and that their best effects are shown when the insulation of the bobbins is not too great and when the surface of the battery is in proportion to the number of turns of the wire.

Hydraulic Cements.

It has been for a long time a matter of reproach to practical science, that notwithstanding the great importance of the subject of cements, and the number of theoretical and experimental researches upon the subject by eminent engineers, we were still left to the most vague hypotheses upon the subject, and no competent chemist appears to have interested himself in the matter. M. Fremy has done away with this reproach, as far as he is concerned, in a memoir presented to the French Academy of Sciences, a digest of which is published in their proceedings of the 15th of May. Vicat assumed the formation of a double silicate of alumina and lime, which, by absorbing water, was the cause of the setting of the hydraulic cements, and this view seemed to be confirmed by finding in the calcined cements a silicate which formed a gelatinous precipitate with an acid, which silicate did not pre-exist in the stone before calcination.

MM. Rivot and Chatonay in an important investigation of cements, to which M. Fremy gives the highest praise, suggested that the calcination of the argillaceous limestone gave rise to an aluminate of lime having the formula Al_20_33Ca0, and to a silicate of lime represented by $Si0_33Ca0$, which salts brought into contact with water form hydrates each with six equivalents of water, and thus cause the settling.

The result of the experiments of M. Fremy is that the settling of cements is due to two different chemical actions: First, to the hydration of the aluminates of lime; and, secondly, to a puzzuolanic action, in which the hydrates of lime combine with the silicates of lime and alumina.

In the course of his experiments, M. Fremy found that alumina is even a better flux for lime than silica, and he suggests that the very basic compounds of these two substances, those, for instance, containing from 80 to 90 per cent. of lime may be useful in the iron furnace, owing to their disposition to absorb sulphur and phosphorus, and thus free the metal from these noxious impurities.

He also finds that no substance is capable of acting as a puzzuolana except the simple or double silicates of lime containing only from 30 to 40 per cent. of silica, and sufficiently basic to form a gelatinous precipitate with acid.

The Functions of Leaves of Plants.

The Proceedings of the French Academy of Sciences contain a communication from M. Boussingault on the subject of the functions of the leaves of plants, which will be of much interest to physiologists. The following is the summary of the results of his experiments:

1. Leaves exposed to the sun-light do not decompose pure carbonic acid, or, if they do, do it with extreme slowness.

2. Under the same circumstances in a mixture of carbonic acid and atmospheric air, they decompose the acid rapidly. The atmospheric air appears to have no active part in this phenomenon.

3. Leaves exposed to the sun rapidly decompose carbonic acid when mixed either with nitrogen or with hydrogen.

Although the decomposition of the acid is a phenomenon of dissociation, M. Boussingault traces a pretty close analogy between it and the slow combustion of phosphorus.

New Electric Battery.

M. Du Chemin, who, in a preceding communication to the Academy of Sciences of Paris, had announced that he had succeeded in replacing Nitric acid in the Bunsen battery by Perchloride of Iron, and the Sulphuric acid by Chloride of Sodium, writes to announce that by substituting for the latter salt the impure Chloride of Potassium of commerce, he has succeeded in increasing the motive and electric force, and that in this way the electric light may easily be obtained.

On Ancient Mortars. By WILLIAM WALLACE, Ph.D., F.R.S.E., F.C.S.

From the London Chemical News, No. 281.

Having, by the kindness of William Clarke, Esq., C.E., who has recently returned from the East, been supplied with specimens of mortars and plasters from well-known ancient buildings in Egypt, Greece, Italy, and the Island of Cyprus, I have submitted a number of them to analysis, with the object of determining several points of interest. The ages of the mortars vary from about 1600 to upwards of 3000 years, thus dating back to the most ancient historical periods. I propose in the present notice to give the results of the analysis of such of the specimens as I have examined.

Mortar of the Great Pyramid.—Two specimens of mortar from the Pyramid of Cheops were examined, one being from the interior, and the other from the outside of the structure. That from the interior was from the great chamber or the passage leading to it. Both specimens present the same appearance—that of a mixture of plaster of a slight pinkish color, with crystalized selenite or gypsum. They do not appear to contain any sand, the silicic acid being evidently in combination with alumina as clay. Part of the selenite was probably burnt, and the result mixed up with burnt lime, ground chalk, or marl, and coarsely-ground selenite. The latter would act the part of sand in our mortars, *i.e.*, prevent undue contraction in drying. The quantity of water is almost exactly what is required to form the ordinary hydrate of sulphate of lime with two equivalents of water. The mortar is easily reduced to fragments, but possesses a moderate degree of tenacity. Prof. C. Piazzi Smyth, who is at present making explorations in the pyramid, and to whom I have communicated the results of my analysis, has informed me that large quantities of gypsum and alabaster are found in its vicinity; and that some enormous slabs of alabaster or selenite have been discovered lining the walls of a large tomb recently opened. The material of which the pyramid itself is constructed being limestone, there is no difficulty in accounting for the presence of the lime.

	Interior.	Exterior.
Sulphate of lime, hydrated,	81·50*	82·89*
Carbonate of lime (CO_2 calculated),	9·47	9·80
Carbonate of Magnesia (do.),	·59	·79
Oxide of iron,	·25	·21
Alumina,	2·41	3·00
Silicic acid,	5·30	4·30
	99·52	100·99

Ancient Phœnician Mortars from Cyprus.—Two specimens were obtained from Cyprus. The first is from the ruins of a temple near Larnaca, the highest stone of which at present remaining is five feet below the level of the ground, and the lowest about eighteen feet. Mr. Clarke supposes this to be the most ancient mortar in existence, and it certainly is one of the best I have ever seen. It is exceedingly hard and firm, and appears to have been made of a mixture of burnt

* Water by actual estimation, 16·66, 17·38.

lime, sharp sand, and gravel, some of the fragments being about half an inch diameter. On solution in hydrochloric acid, it gave a small quantity of soluble silica, amounting to ·52 per cent.

The other specimen from Cyprus is a cement used for joining water pipes. These pipes were found near Larnaca, ten feet below the surface of the ground, and bear evidence of extreme antiquity; they are of red clay, about eleven inches in diameter, and are connected by spigot and fawcet joints, the intervening spaces being filled with the cement, and afterwards coated with a black substance which was found to be bitumen. This mortar or cement is very hard and perfectly white in color. It will be observed that in both of these Phœnician mortars the lime is almost completely carbonated.

	Temple.	Cement.
Lime,	26·40	51·58
Magnesia,	·97	·70
Sulphuric acid,	·21	·82
Carbonic acid,	20·23	40·60
Sesquioxide of iron,	·99	—
Alumina,	21·6	·40
Silicic acid and fine sand,	16·20	·96
Coarse sand,	3·37	—
Small stones,	28·63	—
Organic matter,	·56	·24
Water,	·54	3·09
	100·26	98·39

Ancient Greek Mortars.—The first specimen is taken from a part of the Pnyx, the platform from which Demosthenes and Pericles delivered many of their orations. It has been long exposed to the action of the weather, is very hard, and of a greyish-white color. The other specimen is plaster from the interior of an ancient temple at Pentelicus, near Athens. It has not been exposed to the weather, the temple being in a cave; it is of a pale cream color, and moderately hard. The analytical results are the following:

	Pnyx.	Temple at Pentelicus.
Lime,	45·70	49·65
Magnesia,	1·00	1·09
Sulphuric acid,	—	1·04
Carbonic acid,	37·00	38·33
Sesquioxide of iron,	·92	·82
Alumina,	2·64	·98
Silicic acid and sand,	12·06	3·90
Water,	·36	3·07
	99·68	98·88

In the mortar from the Pnyx the carbonic acid is exactly the amount required by the lime and the magnesia, supposing both to be completely carbonated; in that from the temple, the carbonating is nearly but not quite complete.

Ancient Roman Mortars.—These differ from those already mentioned in being evidently prepared by mixing with burnt lime, not sand, but puzzuolana, or what is commonly, although improperly, called volcanic ash. Of these, four specimens were examined, but two

only of the analysis were completed, owing to deficiency of material. The first in the following table was taken from Adrian's Villa at Tivoli, near Rome; it is a tolerably hard and firm mortar, of a rather dark-grey color.

The second is plaster from the interior of a wall at Herculaneum; it is hard, evidently exposed on one side to the action of hot volcanic mud, and of a red tint. The third specimen is from the roof of the Latin tombs near Rome, of a pale reddish-brown color. The fourth is a cement or mortar from a mosaic forming the floor of the baths of Caracalla, Rome. All these mortars were hard and firm, and contained an appreciable amount of silicic acid in combination:

	Adrian's Villa.	Herculaneum.	Latin tombs.	Mosaic.
Lime,	15·30	29·88	19·71	25·19
Magnesia,	·30	·25	·71	·90
Potash,	1·01	3·40	not estimated.	
Soda,	2·12	3·49	not estimated.	
Carbonic acid,	11·80	23·80	13·61	17·97
Peroxide of iron,	4·92	2·32	1·23	3·67
Alumina,	14·70	2·86	16·39	10·64
Silicic acid and sand,	41·10	33·36	36·26	30·24
Organic matter,	2·28	1·50	—	2·48
Water,	5·20	1·00	8·20	5·50
	98·73	101·86		

General Remarks.—These analyses appear to show that the lime in mortars and plasters becomes, in the course of time, completely carbonated, and does not form a combination consisting of $CaO,HO + CaO,CO_2$, a conclusion that has been arrived at by some authorities. They also show that in all cases where the mortar is freely exposed to the weather, a certain proportion of alkaline or earthy silicate is formed, which in all probability confers additional hardness, and that those mortars are the hardest which have been long below ground. It is well known to builders that those walls are strongest that are built during a rainy season, and that when mortar dries quickly it becomes crumbly and possesses little binding power. When kept wet for some time, a small proportion of silicate of lime will be formed, which will not only make the mortar itself harder, but will unite it more firmly with the stone. It is curious that the mortar which is probably the most ancient, (the specimen from a Phœnician temple,) is by far the hardest and firmest; in fact, like a piece of rock. It is a concrete rather than a mortar, and its excellence seems to indicate that a large grained sand is best for building purposes, and that even small gravel may, in certain cases, be used with advantage.

Mechanics' Institution, Glasgow.

Action of Sulphur in the Voltaic Battery.

M. Blanc, a young telegraphic operator in France, proposed to the Directors of the telegraphs a new pile which is described as follows by M. Matteucci:

"M. Blanc showed me a pile formed by a plate of zinc immersed

in salt water with a sheet of lead galvanically covered with copper. The circuit having been closed, with a galvanometer in circuit, and the needle being settled at 0°, M. Blanc adds some 15 or 20 grammes of flour of sulphur to the liquid, and stirs so as to make a thin paste. At once the needle begins to rise, and after some hours attains the same deviation as though a plate of copper had been employed in a cell fitted with sulphate of copper, in place of the sheet of lead."

M. Matteucci, after satisfying himself that this pile gives a current nearly as strong as a Daniell battery, and constant for four or five days, during which the current was permanently closed, studied its phenomena, and he communicated his results to the Academy of Sciences at Paris. His conclusions are as follows:

First. Sulphur, in a state of powder, placed in contact with the electro-negative elements of a pile formed of zinc, copper, and a solution of sea-salt, augments considerably the electro-motive force, the constancy, and the duration of the battery. It may be hoped that by the use of sulphur a voltaic combination may be obtained presenting some advantages over the batteries now generally used in the arts.

Secondly. The sulphur, although insoluble and non-conducting, enters into combination with the sodium set free by the current. There remains to be explained the action exerted by a very small quantity of sulphuret of copper which is shown by experiment to be indispensable.

Hot-air Engine.

MM. Burdin and Bourget present for the opinion of the Academy of Sciences of France a plan of hot-air engine from which they believe an economy of at least one-half the fuel may be obtained, and which they desire to construct and experiment upon at the expense of the government.

The plan has simplicity at least. "Let there be an ordinary furnace, such as is used for steam engine boilers, the products of combustion of which escape into the chimney after descending along an inclined plane. Let the atmospheric air be first compressed to two atmospheres in small parallel tubes lodged in the flue, the air entering at the lowest point and consequently rising." Then follows a very rational calculation of the length and diameter of the tubes necessary, and a more complicated account of the engine. The theory is excellent; if it should succeed in practice we will return to it.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, May 18th, 1865.

The meeting was called to order with the President, Wm. Sellers, in the chair.

The minutes of the last meeting were read and approved.

The minutes of the Board of Managers were reported, as also those of the Standing Committees, and the following donations were reported: From the Royal Astronomical Society and the Society of Arts, London; the Canadian Institute of Toronto, Canada; the Nova Scotian Institute of Natural Sciences, Halifax, Nova Scotia; the Young Men's Association, New York; and from Alexander Brown, Esq., Joel Giles, Esq., and Prof. J. F. Frazer, Philadelphia.

The Committees on Weights, Measures, &c., reported progress. The Committee on steam expansion reported that the experiments with the first cylinder had been completed, and that those with the second were, at the time of speaking, just begun. The Committee on petition to City Councils with reference to the appointment of an inspector for steam boilers, reported that their petition had been presented, and were discharged.

The chairman of the Committee on Meetings, Prof. F. Rogers, then introduced Mr. Strickland Kneass, who read a paper as follows, on the

Bridge over the Schuylkill River at Chestnut St., Philadelphia.

This bridge is designed for two arches of 185 feet span each, over the water-way, and two in the approaches upon each side of the river, with spans of 60 and 53 feet. On the eastern side there is an additional arch over Twenty-fourth St., the carriage way of which is spanned by an arch of 26 feet, with 8 feet 6 inches rise, and a 7-feet simicircular arch over each footway. The shore spans are segmental arches with versed sines relatively of 18 and 16 feet. The street arch is five centred. See Plate V.

The approach on the east, which is in part sustained by retaining walls, is 595 feet long, from the west line of Twenty-third St., on the east, to the east abutment, measuring from abutment face, and on the west 547½ feet long from the east line of Thirtieth (Bridgewater) St., to west abutment face. The pier is in the middle of the river, about 50 feet west of the channel, and stands about 5 feet in its length (73·57 feet) askew with the general direction of the river at that point, with a width of 16 feet at springing line. The distances between pier and abutments are 185 feet, thus giving a total length to the structure, inclusive of approaches, of 1528½ feet.

The main spans are intended to be segmental arches of cast iron, with a versed sine of 20 feet, the ribs to have a depth of 4 feet, with a sectional area of 147·5 square inches each, which, with six ribs, will give 885·0 square inches of resisting area to each span.

The abutments are 42 feet 2 inches on length of road-way, and 55 feet 2 inches wide at springing line; with three horizontal cells in each, arched at both ends, the thickness of solid work at springing line on face being 16·5 feet, and on back, from which the first stone arch springs, 8 feet. The cells are each 7·5 feet wide, with piers 4·6 wide between. See Detailed Plans, Plate VI.

The masonry in main abutments and pier, as well as the abutments and piers of approach arches, are faced with closely cut granite, from the quarries of Fox Island, off the coast of Maine, near Rockland; it

is laid with the Flemish bond (or alternate header and stretcher), with face "dabbed" and "drafted"; no stretcher has less than 2 feet bed and 6 feet length, no header less than 4 feet length with 2 feet face, the courses varying in thickness from 20 inches to 2 feet. The backing, which is from the Leiperville quarries, is generally laid with roughly dressed beds and builds, in no case having a level surface across the work; this arrangement was also carried out upon the main pier and approach abutments.

The site of bridge was occupied by wharves, and much labor and difficulty was experienced in arranging for the coffer-dams, preparatory to the excavation for abutment foundations. Upon the eastern side the rock is at a depth of 20 feet below ordinary high water, and upon the face line of work bare of earth, and well adapted in its surface for a coffer-dam. As far as practicable the material at site of abutment was dredged out before the coffer-dam was placed.

It was about 87 feet long on face, 23 feet deep, and 9 feet thick, with wings 8 feet wide running back fifty feet into the shore, built of wharf timber laid close, with ties every 8 feet in each course, dovetailed into sides, with interior braces to resist outer pressure; the wings were in part sheet piling secured with walling pieces.

The filling or puddling for dam was entirely gravel as it came from pit, yet not what would be called "clean gravel." The rise of tide is 6 feet, which gave 14 feet water at low tide. The dam was remarkably free from leaks, and was kept clear by a few hours use per day of a 6-inch Alden's (centrifugal) pump, driven by an Archambault portable engine, at a speed of three hundred revolutions per minute.

The rock was leveled in three benches, the back of abutment being 5 feet higher than the face. (Immediately at back of abutment was found the face of wall that formerly enclosed the basin from which, in early days, water for city supply was pumped.)

The western abutment is situated upon what was the river flats, the rock, from its inclination westward, running there to a depth of 38 feet below high water, was covered with a 5-feet stratum of gravel, and twenty-seven feet of marsh mud.

We here commenced operations after the old wharfing was removed, by driving piles over the area to be built upon; beginning at the back course (of necessity), and working forward; the design was to use hemlock, but the lower stratum of gravel was so compact that it was impossible to use them without their breaking before reaching the rock, or so brooming at their heads as to prevent a solid bearing; they were thrown aside and white oak adopted. Where the rock could not be reached by the piles, the limit for driving was to allow a 20-feet fall with a 1200 pound hammer, giving $\frac{3}{4}$-inch penetration. *Arch. and Eng. Journal*, 1852, page 37. $\frac{3}{4}$-inch will bear with safety 48,000 lbs. This was determined from the practical experiments made by Major Saunders at Fort Delaware, which was the best data at hand, and proved to be perfectly reliable, as the abutment has stood firm and level. The greatest weight upon each pile with superstructure in position will be 40,000 pounds.

After the piles were driven, a coffer-dam, similar to that described for the eastern abutment, was constructed, which, being pumped out, the piles were cut off at an elevation of 2 feet below low water, except the first four lines from the front, which were cut at 6 feet. The mud was then excavated from around the pile-heads to a depth of 2·5 feet, and replaced with béton, composed of hydraulic cement, coarse gravel, spawls, and brickbats; proportions, one part cement, one part sand, three parts stone or gravel. This was carefully leveled at pile heads when a 12×12 squared white oak sill was set laterally upon the pile heads; coarse grouting was then poured into all the interstices, so as to make the bearing of sills equal upon both piles and béton; upon the white oak sills were placed 12×12 hemlock squared timber with spaces of three inches between each stick, gained three inches upon the oak sills, and bolted through to pile head; all the openings were, as before, filled with grout made of hydraulic lime, in proportion of 1½ of sand to 1 of cement, varying somewhat with the quality of the cement. Upon this platform was commenced the masonry, which was laid in hydraulic lime to a point above high water, after which the face joints were lipped with cement and the interior grouted with lime mortar.

The foundations of the western approach pier and abutments were prepared in the same manner.

The piles were driven 2½ feet from centre to centre, requiring 397 for main abutment, and 194 in the approach pier and abutment. There were about 8 miles in length of piling driven, including the retaining wall foundations.

The pier is located in the middle of the river, and erected upon a crib foundation, (Plate VI,) made of 12×12 inch yellow pine timber carefully squared; it is 28 feet high, at base 86½ feet long, and 31 feet wide; at about 7 feet below low water it is 79½ feet long and 24 feet wide, reducing with a regular batir from base. At this point there is an offset of one foot all around, and is then continued up plumb for a further distance of 5 feet, finishing at 3½ feet below low water. In plan it is divided into 66 cells, having 17 courses crosswise, and 8 courses lengthwise. The greater portion of these cells are entirely open to the river bottom, only a sufficient number being platformed to contain the sinking weight which is placed on the second course from the bottom. Each course of timber was notched and bolted to prevent lifting or sliding, and laid together as closely as carefully counter hewed timber can be placed. It was built alongside of the pier site, and loaded as the work progressed, so that its top, while building, was always at water surface.

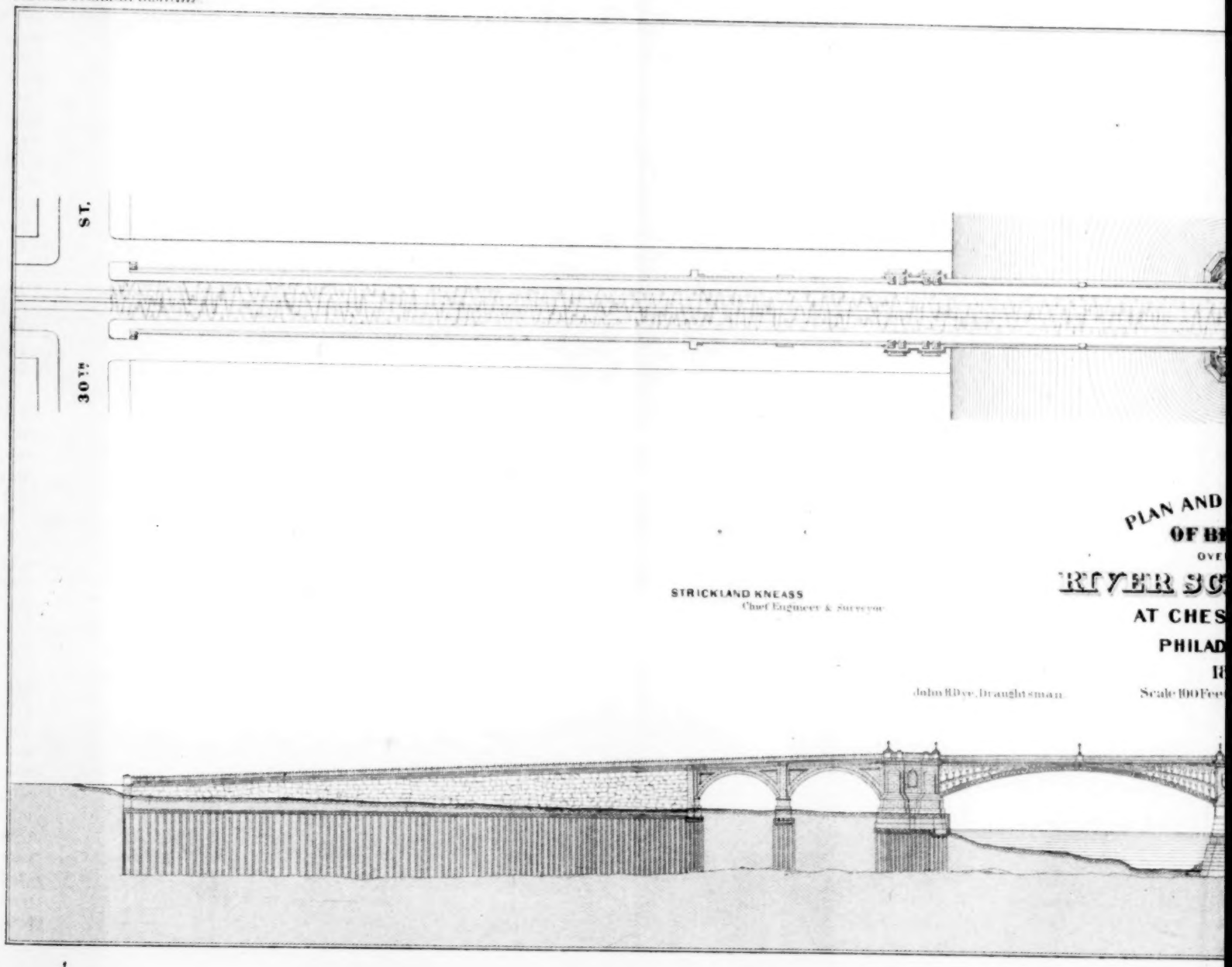
In preparing for the crib, it was ascertained by sounding that there was comparatively a level rock bottom, covered with about 8 feet depth of gravel. This was removed by dredging, when a framework was constructed, conforming to shape of crib and showing the position of each line of timber, in both directions upon the bottom courses; this was floated to and accurately anchored in position upon the pier site, and from it the soundings to rock were made along each line of timber as proposed. These were reduced to a common data by tide observations

taken simultaneously with each sounding, thus giving a correct topographical plan of the rock surface, upon which the crib must set when in place, and to conform to which the bottom of crib must be constructed, to give, when in position, a top surface (level) for the commencement of the masonry. When prepared to set, the crib was floated to position, which was defined by a wire stretched between the abutments upon the centre line of bridge (then partially built), having a plummet hanging at the middle. Its line up and down the river was fixed by a point previously established on the railing of Market St. bridge, (500 feet above;) upon the crib were uprights marking the middle at upper and lower ends, and also a middle point on the centre line. When, therefore, the plummet hung over the middle point, and the two end uprights ranged with the point upon the bridge above, the location must be as intended. There was no difficulty experienced in placing the crib as desired; guys were arranged at each end of crib, so as to change its position with reference to its right angle line to bridge, working against a timber float fixed between crib and the western coffer-dam as a centre fulcrum, its position with reference to centre line being regulated by a capstan upon a scow secured to the pier of bridge above which worked it up stream, while the falling tide allowed its dropping down stream; when hauled out to position, it contained 300 tons of stone, and at sinking 150 tons more were thrown into the platformed cells.

This was done in November, 1862, and was allowed to remain loaded with about 700 tons of rough stone, until the following spring, when the other cells were filled with 1216 tons of broken stone and coarse gravel screenings to within a few inches of the top, making a total of 1666 tons of ballast in crib. A close laid platform, 12 inches thick, was laid over it so as to take up an inclination of three inches in its width, and enable the stone courses to start with level beds.

This platform was 2½ feet below low water, and had secured upon it a line of light timber laid to conform to shape of pier, so that the platform being accurately set and secured in position upon the crib, the masons need have no further guide (being below water level) in placing the stone cut to size and shape, than by being assured that they were full against the timber set to regulate them.

In the construction of this crib, much thought was given and inquiry made, to form some idea as to how much the top elevation would be reduced, by the weight of finished pier closing up the joints, and compressing the timber, which, from long immersion, would be water-soaked and swollen; this was important, for it was desirable to finish the springing line of the arches at the same level with the abutments without interfering materially with the courses of stone as laid out, and the stone-cutters should have the dimensions of the courses in hand to prevent unnecessary delay. Nothing could be found upon which an opinion might be based, but an allowance in its constructed height was made, which proved to be as near correct as could be hoped for, and caused but little adjusting of the courses as the work proceeded. The compression was as follows: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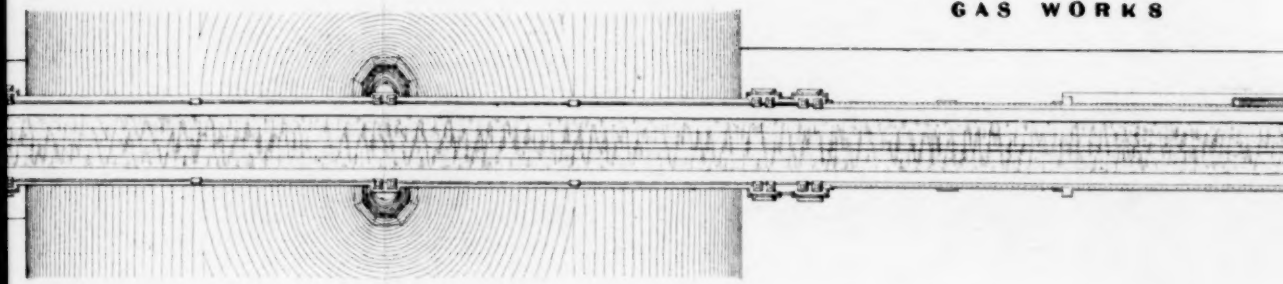


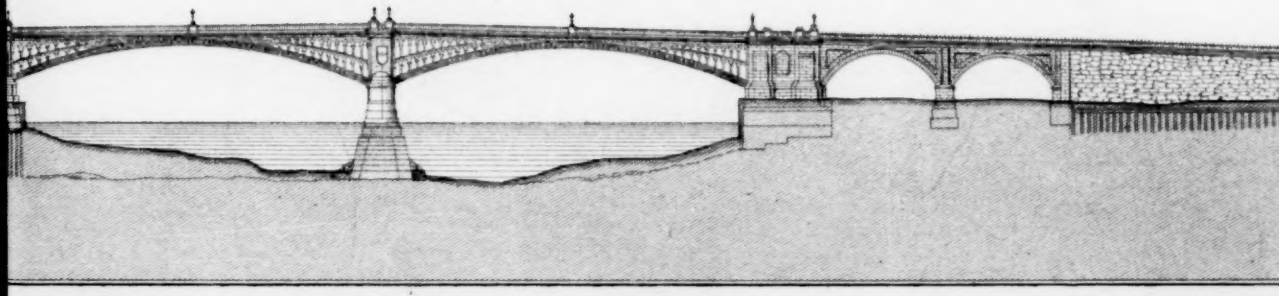
PLAN AND ELEVATION
OF BRIDGE
OVER THE
RIVER SCHUYLKILL
AT CHESTNUT ST.
PHILADELPHIA
1865.

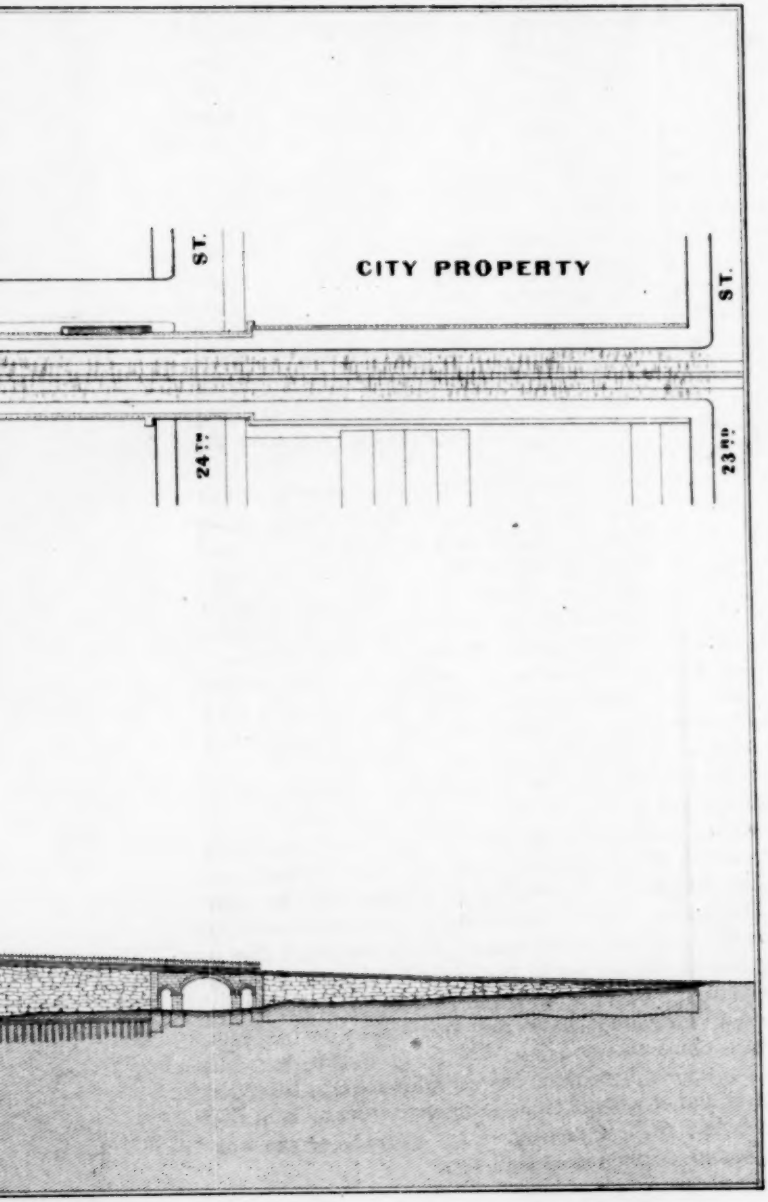
JAMES R. Mc CLURE.
Ass't Engineer

n H Dye, Draughtsman.

Scale 100 Feet to one inch.

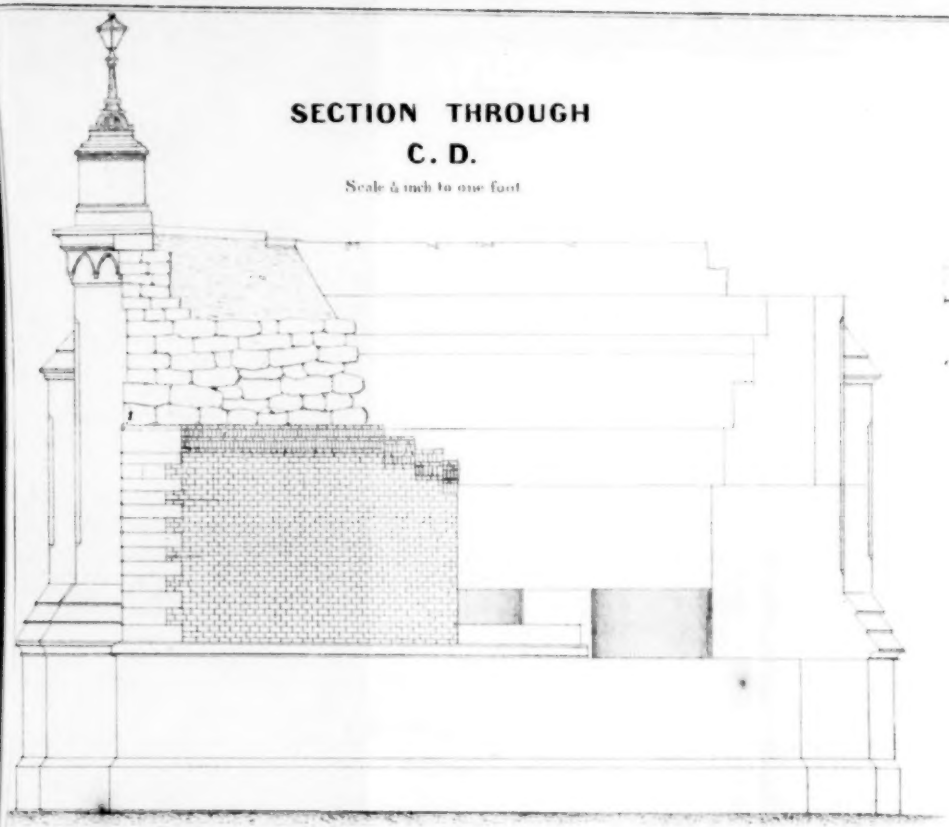
Jas. Gugan, lith.

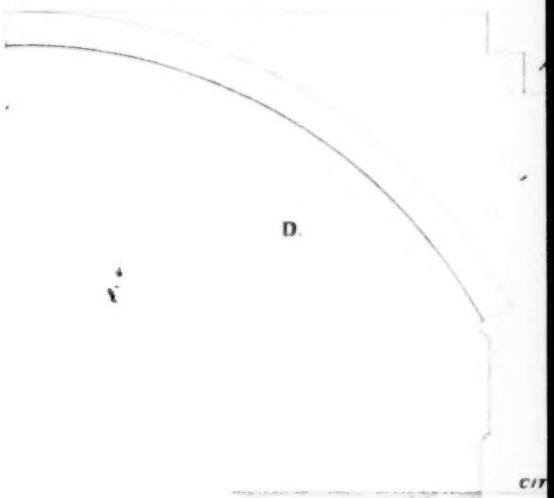



ST.
CITY PROPERTY
ST.
24TH
23RD

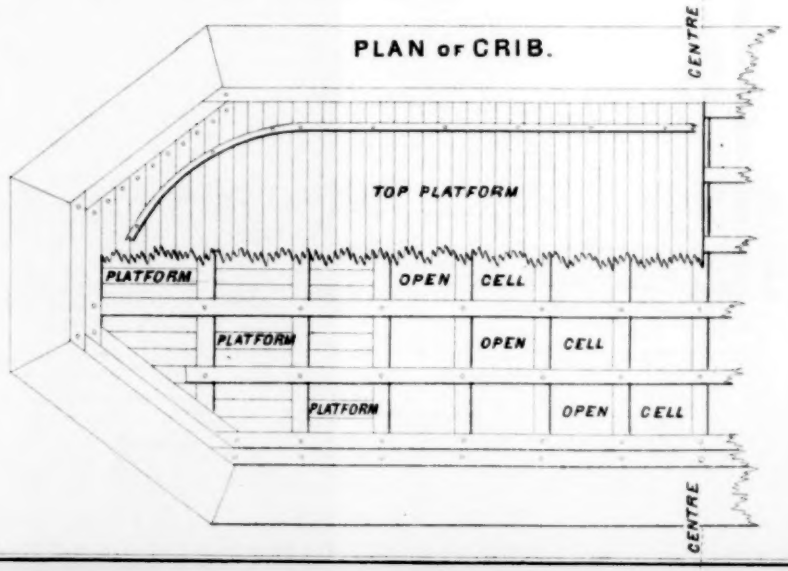
SECTION THROUGH C. D.

Scale ⅛ inch to one foot

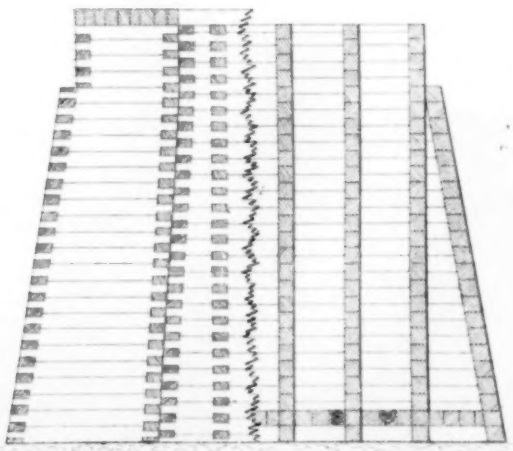




PLAN OF CRIB.



CRIB. END VIEW & SECTION.



C.

D.

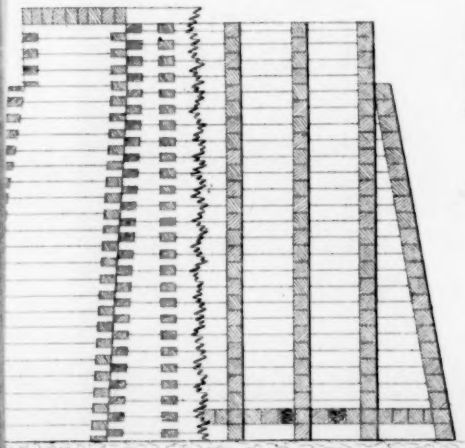
SECTION
OF
ABUTMENT AND APPROACH ARCH
THROUGH
A. B.

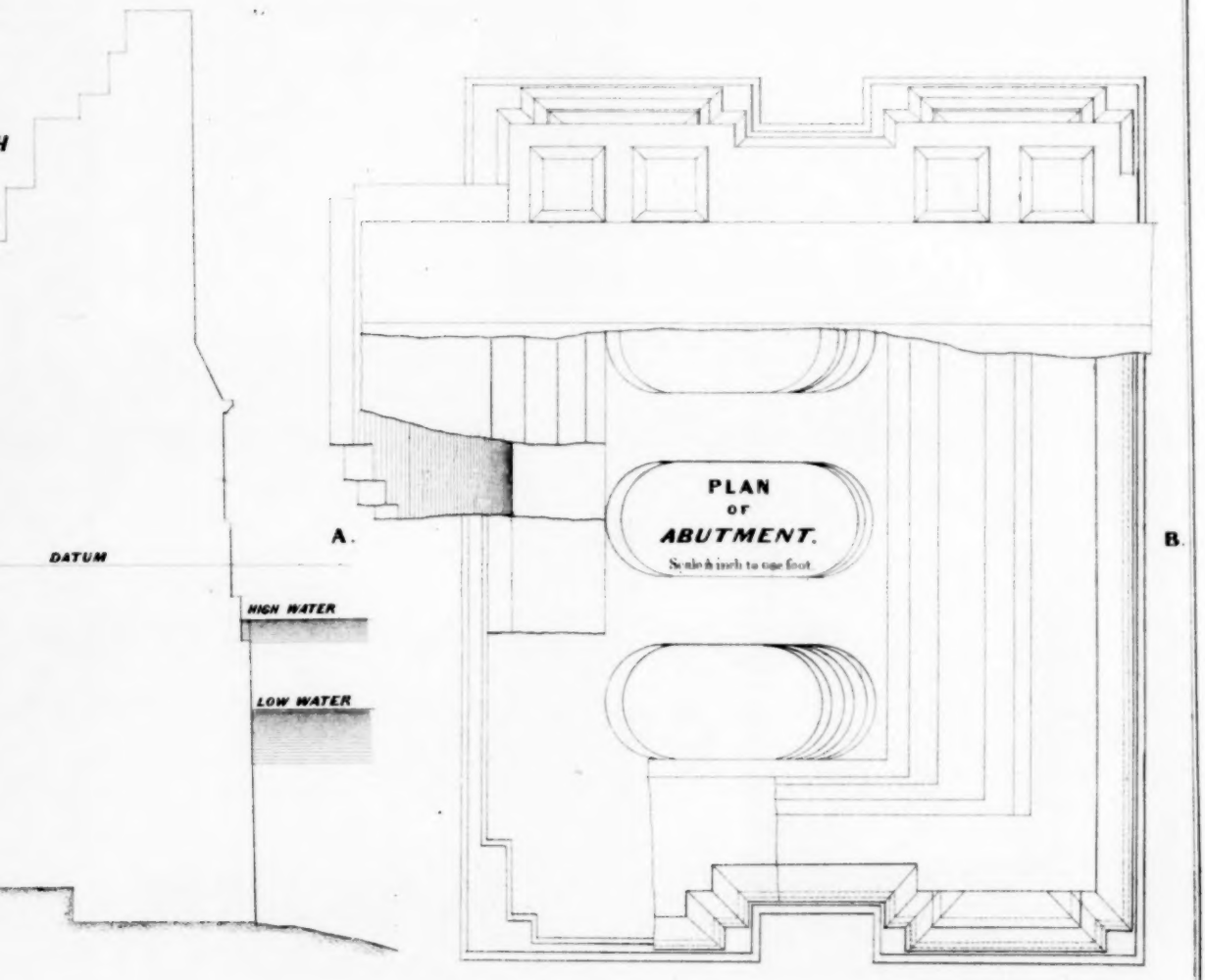
Scale ¼ inch to one foot

CITY

DATUM

CRIB.
END VIEW & SECTION.




DATUM
HIGH WATER
LOW WATER
A.
B.
PLAN
OF
ABUTMENT.
Scale 1 inch to one foot

With	380 tons,	Compressed	$\frac{9}{16}$ of an inch.
"	726 "	"	$1\frac{1}{4}$ inches.
"	860 "	"	$1\frac{7}{8}$ "
"	1134 "	"	2 "
"	1268 "	"	$2\frac{5}{16}$ "
"	1529 "	"	$3\frac{5}{8}$ "
"	2131 "	"	$4\frac{1}{8}$ "
"	2237 "	"	$4\frac{7}{16}$ "
"	3020 "	"	$6\frac{1}{2}$ "
"	3255 "	"	$6\frac{7}{8}$ "

What proportions of this were consumed by the small irregularities on the bottom, there is no means of ascertaining.

The total weight of masonry in pier is 3255 tons.

The retaining walls are built of rubble work. From Twenty-third to Twenty-fourth Sts. the foundation is upon gravel; the remainder on the east side, or between Twenty-fourth St. and the approach arches, and on the west side entire from the west abutment of the approach arches to Bridgewater St., 378 feet, is upon piles. They are driven in three rows, varying in distance apart from four feet to five feet, proportional to the height of the wall. The level of the foundation platform is at mean tide, and is made of 12×12 inch hemlock stringers set upon the pile heads, and covered with hemlock plank 6 inches thick, bolted through stringers into each pile head; they are laid closely and transversely with line of wall. The walls are proportioned to ·3 of their height at $\frac{1}{3}$ from platform, and built with a batir of 0·1 per foot; instead of béton around the heads of the piles under retaining walls, sand was used to equalize the bearing; the piles here reach the rock and are 40 feet long below the platform.

The approach arches are laid with a thickness of 2·5 sheeting, faced with granite ring stone, the interior being brick. The brick-work is not laid in concentric rings, but built up so as to form voissoirs of a length of 4 feet 9 inches on the arch at intradoes; the bricks were laid wet with as close joints as is judicious with brick-work, and in their courses, to conform to the width of the ring stones on intrado, which was $14\frac{5}{16}$ inches; they are alternately $2\frac{1}{2}$ feet and $3\frac{1}{2}$ feet long. In putting up this work an attempt was made to prevent the cracks which ordinarily occur in a brick arch where it is faced with stone, by building the outer ring and brick sheeting up simultaneously, as is usual, closing the brick arch, but filling the place of the keystone in the outer ring with wood, hoping that when the centering was let down, the less motion in the rings in comparison with the brick-work, owing to the fewer and closer joints, would be compensated for through the different joints of the ring, and be taken up by the compression of the wooden key, and thus give a uniform pressure on the brick and stone. This was not attended with success; for although no cracks of any moment were apparent in the brick-work, yet the closing of its many joints did not divide its motion among the voissoirs composing the outer face, but moved the arch of ring stone entire upon its spring, and placed the bearing upon the inner

edge or intrado. The result was that several of the stones at the spring flushed on their inner face sufficiently to bring the back of voissoir to its bearing. This did not in any way affect the stability of the arch, but proved the great difficulty and care required in combining stone rings, laid as they usually are, with close joints and brick sheeting. In turning the western arches a further attempt will be made to combine the two classes of masonry by making larger joints between the rings.

There was none of this difficulty in erecting the arch over Twenty-fourth St., which was built with brick and stone, and is perfect in its inner surface, although the key was placed in at the same time the brick-work was closed. This was probably caused by the more open joints of the rings, and the shape of the arch, which is a five centre, while the others are segmental.

The approaches will be upon an ascending grade from Twenty-third St., westward 110 feet, 2·24 feet per 100 feet, then 220 feet, 4·0 feet per 100, then to the bridge abutment 3·2 per 100; upon the bridge itself the grades will form an arc of a circle 4900 feet radius, rising 2·35 feet per 100 from abutments to middle of span, then 0·6 per 100 to the pier, making the level of pier 2·75 feet higher than the abutments. From the west abutment to Bridgewater St. the grade descends at the rate of 4·0 feet per 100.

The carriage-way of the approaches and superstructure will be paved with granite blocks, having a width of 3½ inches and not less than 8 inches long laid in courses; they will be 5 inches deep and laid upon a 12-inch bed of anthracite coal ashes covered with 4 inches of clean gravel; the footway to be of brick laid in the usual mode.

The width of carriage-way will be twenty-six feet, or the same as Chestnut St., on the east, of which it is a continuation, with footways of 8 feet.

This work was commenced Sept. 19, 1861, and the first stone for the erection of the bridge was laid Dec. 17, of the same year, but, owing to the difficulty of obtaining material and labor, its completion has been much delayed. The masonry here described was ready for the superstructure in June, 1864, but, owing to continued delay at the iron works from the want of machinery, &c., the construction of the "false works" preparatory to the erection of the superstructure has but lately been commenced, yet we may, with some confidence, hope that the entire work will be completed during the coming autumn.

The magnitude of this work may be understood when we state that there are 573,415 cubic feet or near 23,000 perches of stone laid in the abutments, piers, and approaches, 99,000 cubic feet of which are carefully and accurately cut granite, the Gothic ornamental cornice and entablature being in style to conform to design of bridge superstructure, as is also the general plan of the abutments.

Messrs. Clark, McGrann and Kennedy are the contractors for the stone work. Their final estimate will be about $355,000, and it is but proper to say, that had not the rebellion, which broke out April 14th, 1861, shortly before the beginning of this work, so increased all

values of labor and materials as to require an advance by the city of 27½ per cent. upon the schedule of prices in the contract, the first estimate of the work herein described would have been several thousand dollars less than the original estimate.

At the conclusion of the paper, some questions were asked and answered, as follows:

Prof. Fairman Rogers.—To what fact is due the non leakage of the dam? Was the dam itself tight? or was the gravel so dirty as to serve the purposes of stopping the leaks? This is the first instance of this kind I have ever noticed.

Mr. K.—We have found that gravel as *taken from the pit* makes better puddling for our coffer-dams than the mixed clay which we ordinarily procure. I attribute the tightness in the present case, however, not only to the use of gravel, but also to the simple fact of using the wharf-timber, laying it closely with fewer joints. The old-fashioned method of constructing these coffer-dams, was to make an expensive frame-work, with many lines of timber, and then sheeting up and down, which makes a great many joints.

Prof. Fairman Rogers.—Again; I don't exactly understand how the béton was confined at the western abutment.

Mr. K.—After the piles had been cut off level, the space between them was excavated to a depth of 2½ feet below the pile-heads, and where the mud was not sufficiently firm around the outer edge of piling to form a bank to hold the béton in place, we drove sheet piling. But this was required only for a length of some six or eight feet. The western approach pier foundation is of the same character.

Secretary's Report.

Engineering, Works.—We have to notice, under this head, the sinking of a new artesian well in Paris, at the place Hébert. Great and unexpected difficulties have been encountered in this work. At a depth of about 70 feet, a quicksand was struck, which occasioned a deflection in the tube lining, used for enclosing the well shaft, on account of which it had to be drawn up, and masonry, in successive rings supported on wooden curbs, substituted. A depth of 118 feet only has now been reached, but the progress seems likely to be more rapid and substantial in future.

Of a different character, as regards ease of execution, has been the advance of the Chicago tunnel, under lake Michigan. This has advanced nearly ⅓ of a mile under the lake, through an uninterrupted stratum of tough clay. Some boulders have been encountered, but these have been removed, piecemeal or entire, without serious drawback, and the work has throughout progressed with most gratifying facility. It was intended to cut this tunnel from three faces, by sinking a coffer-dam about a mile from shore, and then working both outward and inward from this point. This was, however, prevented by a variety of causes, and the work has been carried out thus far from the shore face alone.

Mechanical Engineering.—We observe a patent lately issued for the construction of the "units" (used in the spherical or Harrison

boiler fully described, vol. xlviii, p. 38, of the *Journal*) from wrought iron, by the process of pressing with a large die.

We thus see the possibility of employing the strongest material for this strongest shape of steam generator, and thus attaining a combination of unprecedented endurance.

In the last number of the *Annales des Mines*, we notice an excellent article on smoke burning locomotives for bituminous coal, in which the economy and usefulness of this arrangement, is well exhibited in the results of some experiments on the railroads of the East and of Orleans. The combustion is rendered thorough in these engines by the use of an inclined grate, down which the fuel is gradually fed, as it consumes, and a fire bridge of refractory material, leaving a large combustion chamber for the gases before they enter the tubes. We would call attention in this place to a report on coal burning locomotives, made to the Pennsylvania Central Railroad Company by Mr. (now General) W. J. Palmer, some years since. Here the employment of a bridge of fire-brick is strongly advocated, on the ground that it acts as a reservoir of heat, keeping up the necessary temperature, when, from opening the furnace door, in stoking, &c., it is most needed, to insure the inflammation and combustion of the chilled gases. The curious fact is noticed in this report, that the amount of fuel yearly thrown away as smoke, on such a road as the above, is in the neighborhood of *seventy tons*.

Mechanics, Theoretical.—Prof. Rood, of New York, has shown that if a gyrascope, while spinning, is made to revolve about the line which is common to the plane of its wheel and ring, (which motion would tend to develop a pressure alternately in opposite directions upon its supports,) its moving force will be taken up by this action, and in place of running 16 minutes, for example, it is brought to rest in about 20 seconds. Opposing motions or forces, as we know, destroy each other in a mechanical sense, or, in other words, are changed in form, as into heat, &c., but the above illustration is a very striking, neat, and clear means of demonstrating the fact of this destruction, and of exhibiting it in a new light. For details, see *Silliman's Journal*, May, 1865, p. 259.

Our attention having been drawn to a misprint in a previous volume of the *Journal*, we take this opportunity of correcting it. In the description of J. Harrar's skate fastening, vol. xlviii, p. 426, the sentence should run, "securing the skate to the heel of the shoe or boot."

Physics, Electricity, Thermo-electric Piles.—Bunsen has published an account of a new combination, consisting of native copper pyrites and an alloy of, antimony 2: 1 tin; or of pyrites and copper, by which a greatly increased thermo-electric force may be developed. Such an element heated to 60° Cent., and to the melting point of tin, at its opposite ends, gives a force ten times greater than that of a bismuth and antimony element at the temperatures of 0° and 100° C. It is requisite, however, that the pyrites should be used in its natural state. If fused and cast it loses all its efficiency. Pyrolusite (MuO_2) and platinum are also found, by this same experimenter, to give a power-

ful current, though opposing great resistance to its transmission.—*Silliman's Journal*, May, 1865, p. 219.

In another article (p. 205 of the *Cosmos*, Feb. 22, 1865) we see an account of various experiments in the above direction, made by M. E. Becquerel, and by his father, at various dates from 1827 to the present time. From this it would appear that a copper wire sulphuretted (sulphuré) on the surface, would form with pure copper an energetic thermo-electric pile. M. Becquerel has exhibited to the Academy, the model of a pile, constructed according to his directions, of metallic copper and its sulphide. In this, each element consists of a plate of CuS_2, about 3 inches long, $1\frac{1}{2}$ inches broad, and $\frac{3}{8}$-inch thick, provided with caps of copper at each end, which are connected in such an order by copper rods, that one end of the group being heated and the other cooled, a current may be established.

It would appear from the article above quoted, that artificial *sulphide of copper may be used* in an efficient thermo-electric pile. We would suggest in this connexion the question: Is there not some chemical action, as well as one purely thermo-electric, in the use of this combination?

In the proceedings of the Royal Irish Academy, we see the description of a Ruhmkorff coil, made with iron wire for its outer helix, wound in three flat rolls or block wheels; 30 miles of $\frac{1}{100}$-inch wire are used, and the spark obtained is 16 inches. This coil was constructed by Dr. Collan, of Maynooth. The use of iron wire, in such a case, seems judicious in certain respects, its resistance or low conducting power being, perhaps, advantageous; but the facts which have been brought to our notice, with regard to the giving out of small induction medical coils, made of this material, would make us anxious about the longevity of the apparatus in question.

Ruhmkorff coils of very minute proportions, but capable of demonstrating satisfactorily the properties of the induced spark, have been constructed by M. Gaiffe of Paris. Their efficiency, according to M. Du Moncel, results from the complete insulation of their various parts. The length of the bobbins is less than three inches, and the base on which they rest, and which carries or contains all the other parts, is $4\frac{3}{4}$ by 3 inches.

Light.—We state, for the benefit of those interested in the matter, the details of apparatus (lately used in the lecture brought out by the Institute, at the Opera House) for producing an artificial rainbow.

The light employed was the ordinary lime light, with hydrogen burned directly from a large "generator" provided with a Wolf's or washing bottle, and oxygen from a gas-bag, both under pressure of 15 inches water gauge, or about $\frac{5}{8}$-lb. per square inch.

A simple concentric jet and square prism of lime were employed, no adjustment of the latter being required during the limited time of the experiment.

This light was placed in an ordinary magic lantern box, with two $4\frac{1}{2}$ inch condensers, having a combined focus of 2 inches. A single, meniscus, uncorrected object lens, of 7 inches focus and $1\frac{3}{4}$ inches

aperture, completed this apparatus. In the usual place for the object or picture was inserted a brass plate, having an arched opening, with a span of $2\frac{3}{8}$ inches, and a radius of $1\frac{5}{8}$ inches on the outside, (therefore, not quite an entire semicircle,) and a width of aperture of $\frac{1}{8}$-inch. A glass slide painted black, with the exception of a similar arch left clear, serves almost as well. The image of this arch being focused on the screen, about 50 to 60 feet off, the lantern is inclined upward at a great angle, and a hollow prism filled with bisulphide of carbon, is held across the front of the object glass, at the angle of least refraction. This hollow prism was made by grinding away two vertical edges of a square bottle, 2 inches on base by 3 inches high, and cementing plates of glass, on the skeleton wedge so obtained, with the mixture of molassess and glue used for "inking rolls." A *square* bottle was used out of deference to the recommendation in Frick's Physical Technics; but many difficulties were experienced in consequence, and we would recommend, and shall ourselves employ, in future, a stout, *round, German* bottle. To develop the effect of this experiment, in the case referred to already, the stage was set with wings to represent a forest, a low rock background, and a white "horizon drop" or rear curtain, which, by proper adjustment of the border lights (throwing it in shade) was made to appear of a graduated dark grey. On this the bow was thrown. The light and intensity of color of the bow was sufficient to allow of a very considerable general illumination of the stage, without bringing the rainbow below (if even *to*) the natural faintness.

We would call attention to the remarkable experiments made by Dr. Tyndall, on obscure heat, from the electric light, a full account of which will be found on a previous page of this *Journal.*

The Spectroscope has received a new and remarkable application, in the direction of astronomy. It has been applied to many of the nebulæ for the purpose of deciding the question of their solid or gaseous condition. Solid bodies incandescent (so highly heated as to give out light), produce a continuous spectrum, exhibiting, more or less clearly, the graduated series of the rainbow tints. Incandescent gases or vapors, on the other hand, (such as the diffused vapor of salt which will give a yellow color to the flame of alcohol,) show no continuous stripe of varying colors, but exhibit only certain defined bands or lines of colored light, characteristic in each case of the substance producing them.

The sun, as we know, gives in this sense a *continuous spectrum*, so do the stars and planets, so does a highly heated bar of metal or wire, and so do our ordinary flames of candles, lamps, gas, and the like, containing, as we know, countless particles of solid carbon, highly heated. We therefore conclude or know, that all these are *solid* sources of light. But flames which do not contain solid matter, carrying only vapors in an incandescent state, such as the alcohol and salt above mentioned, the flame of hydrogen tinged by phosphorus, &c., give us simply isolated and distinct bright lines.

It will be readily seen, therefore, that when, on turning the spec-

troscope upon the famous dumb-bell nebula, we find three bright lines only visible, we have good reason to conclude that this body is not a grand system of suns at an immense distance, but only a diffused hot vapor, possibly near at hand. Some of the nebulæ give us, however, continuous spectra, and these, therefore, retain their place in our estimation, as far-off clusters of suns.

Several nebulæ, completely resolvable, and whose stellar character passed unchallenged, have yielded the secret of their structure to this new questioner. Among these is the famous nebula in the sword-handle of Orion, the annular nebula in Lyra, and the dumb-bell nebula mentioned above.

For a full account of the observations leading to these results, we would refer to a paper by Mr. William Huggins, in the proceedings of the Royal Society, vol. xiv. p. 39, and a paper communicated by Father Seschi to the French Academy of Sciences. *Comptes Rendus*, vol. lx, p. 466, (March 6, 1865.)

Chemistry.—If a small amount of iodine is added to fused sulphur, the whole heated to about its boiling point, and then poured in a thin stream into cold water, it will assume the amorphous or plastic form, as might be expected, but with certain differences of properties as compared with pure sulphur under like treatment. Thus, it is of a rich garnet color, *very* plastic, and agglomerates readily, so that it can be easily worked into a consistent mass; it will retain its plasticity for a much longer period than pure sulphur, not entirely loosing it until about three days after its preparation. A similar result is stated to follow the addition of wax, oil, naphthaline, creasote, camphor, turpentine, &c. All but the first two, moreover, rendering the sulphur insoluble in bisulphide of carbon. Carbon prepared from sugar or from wood, produces like effects, even in so low a proportion as 1 : 1000 parts of sulphur. For full particulars see paper in *Comptes Rendus*, vol. lx., p. 353, (Feb. 13, 1865.) (Specimens of sulphur in its soft state, both pure and as above, were here exhibited.)

We have also to notice an important improvement in the process for revivifying animal charcoal used in sugar refining, lately patented, as we see, in England, by a Mr. Beanes. The "spent char," or charcoal which has lost its decolorizing properties by use, is first heated and dried, then exposed to a current of hydrochloric acid gas, (a large quantity of which it absorbs,) and is then mixed with a further quantity of heated "char," to which it imparts its excess of acid. By this means the lime from the syrup (which has choked up the pores of the charcoal and thus destroyed its efficiency as a decolorizer), is converted into chloride of calcium, which can be readily washed out, after which, the charcoal is reburned, as usual, to remove albuminous matter, and is then found to be in most excellent condition.—See *Chem. News*, Feb. 17, 1865, p. 76. We would call attention to the excellent remarks on this subject by Dr. Crace Calvert, quoted on page 250 *et seq.* of this *Journal*, April 1865.

In a paper read before the London Chemical Society, Dr. Calvert stated some important facts which had come within his notice regarding

the destructive effects of silicate of soda upon cotton fibre when this salt was used as a "dressing to the fabric." The destruction of the cloth was unquestioned, although some uncertainty was expressed in the succeeding discussion, as to the chemical or mechanical cause of the injury, *i. e.*, whether it resulted from decomposition of the silicate and the liberation of caustic alkaline carbonate by the action of carbonic acid in the air, or from a mere crystallization of the salt within the fibres of the fabric.—See *Chem. News*, March 10, 1865, p. 113.

In connexion with this crystallization of a silicate, we would notice a curious experiment in the production of a pseudo-vegetation, analogous to that seen in the moss agate. An account may be found page 120 of the *Chem. News* just referred to, but we will here give a description of the best arrangement of the experiment according to the result of our own trials. A glass jar of any size may be filled with the commercial solution of silicate of soda, diluted by the addition of 5 times its volume of water, and into this should be dropped a few crystals (varying in size from that of peas to that of common chestnuts) of sulphates of iron and of copper. In a few minutes, branches of seeming vegetation (much like certain aquatic plants) will shoot up from these crystals, and in a few hours will reach the level of the liquid and show an extended development. This action is due to the solution of portions of the crystals from time to time, the rising of this solution in the dense silicate, and the union of the metallic base, with silica, to form a solid mineral silicate. The iron salt gives a seeming vegetation of an olive green, the copper of a light blue color. Their combined effect is very beautiful. A little *mineral aquarium* may thus with ease be prepared which will bear careful moving, (two of those, this evening exhibited, were carried half a mile in a basket an hour since,) last for an indefinite period, and serve as an admirable illustration of that process of diffusion or percolation, whose beautiful effects we observe in the moss agate.

We have also found that additional variety may be given by the use of sulphate of nickel, which produces a vegetation of a beautiful emerald-green color, and sulphate of zinc, which develops formations wonderfully like those of the lowest animal organism, such as the gelly-fish, the yeast plant as seen in the microscope, &c.

When the growth of these mineral plants is complete, the whole may be placed under a gentle stream of running water, (as from a spigot,) and the solution thus displaced by fair water.

The addition of chromate of potash to the solution does not, we think, improve the effect.

A convenient form of blow-pipe for organic analysis is described by Dr. Herapath in the *Journal of the London Chemical Society*, Feb. 1864, p. 49. It consists of an ordinary gas pipe, bent into a U form, of which the two limbs are close together. The upper surface of this is pierced with a number of small holes, and a branch pipe is provided, so that air may be blown from the mouth into this tube with the gas which enters it from the mains.

From an accident recorded in the same journal, it appears that in

highly compressed oxygen, masses of iron, (such as the inner surface of a heavy steel receiver, for example,) will burn violently if ignited by such a body as oil, inflamed under like conditions.

We would call attention, lastly, to the translation of an excellent paper on the "Bessemer process of manufacturing steel from pig iron," just published in the *Bulletin* of the American Iron and Steel Association, by R. H. Lamborn, Secretary of the above Institution; and would offer some specimens of the steel which has been so prepared, both in this country and abroad, in a rough and manufactured form.

After the conclusion of the above report, Prof. F. Rogers proposed certain amendments to the By-Laws of the Institute, with a motion providing for their consideration at the next stated meeting, and the preparation of printed copies for the use of the members before that time.

The proposed amendments were then read by the Secretary, the motion was carried, and the meeting was, with the usual form, adjourned.

HENRY MORTON, *Secretary.*

BIBLIOGRAPHICAL NOTICES.

A Treatise on Astronomy. By ELIAS LOOMIS, LL.D. New York: Harper & Bros., 1865, 8vo. pp. 338.

It is but too seldom, upon our side of the Atlantic, that our text-books are written by men of competent knowledge in the science which they profess to teach. Hence, we generally find them to be either a loose combination of heterogeneous material taken from former books, or from the scientific annual, or else we have a dry and indigested mass of practical formulas, which, although useful to the technical artist, are but stumbling-blocks to the learner. The work before us constitutes an honorable exception to the rule. We have here a well arranged treatise upon the fundamental principles of astronomy, demonstrated simply but rigorously, and illustrated and relieved by an account of the physical phenomena of the universe which we believe with the author, to be well calculated to "enhance the interest of the subject," and which, indeed, to the general student of astronomy, are of quite as much importance as the mathematical laws of the system.

The arrangement of the subject is particularly good, and the treatment of each article is sufficiently full without being prolix. We are, however, a little surprised to notice certain omissions of recent researches in astronomy which must be familiar to one of Professor Loomis' information; such as the adherence to Encke's parallax of the sun (8″58) and the consequent distance (95,000,000 miles) of the sun from the earth. We had thought all astronomers were now agreed that the parallax must be increased to something like Leverrier's value (8″95), with which the recent determinations of Winnecke, Stone, and

Hansen very closely agree. A less remarkable omission is that of any mention of Faye's theory of the acceleration of comets, which favorably replaces Encke's resisting medium, inasmuch as it substitutes a familiar cause for an entirely hypothetical one. But these are but slight blemishes, and, indeed, are rather advantages in a text-book, as they serve to keep the teacher wide awake. We can safely and sincerely recommend this book to teachers as an excellent text-book, and hope it may be extensively used.

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A Treatise on the Assaying of Lead, Copper, Silver, Gold, and Mercury. From the German of M. Bodemann and Bruno Kerl. Translated by W. A. Goodyear, Ph. B. Illustrated with plates. New York: John Wiley & Son, 1865, 12mo. pp. 214.

This handy little work is very seasonable here at present, when we are so largely embarking our capital in the development of the almost fabulous resources of our middle and western territory, and we think the translator has done well in reducing the size of his treatise by translating only those parts which relate to what used to be the rarer metals. The work of Bodemann and Kerl is of high authority in Germany; and in metallurgy especially, German authority is in the highest repute throughout the world. We earnestly recommend this treatise to the attention of all who are interested in the metals of which it treats. It purports to be published for the Berzelius Trust Association, and in the title and preface makes mention of the Sheffield Scientific School, both of which we suppose all men are bound to know all about, but of both of which we confess ourselves lamentably ignorant.

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The Pulpit and Rostrum, a New York Serial, Published by Schermerhorn, Bancroft & Co. have published an extra number containing Hon. Edward Bancroft's Oration at the Obsequies of the Late President; the Funeral Ode, by Mr. Bryant; the Emancipation Proclamation; and the Inaugural Address for 1865; and Illustrated by a Portrait of Mr. Lincoln.

The documents are well and clearly printed, of a convenient size for preservation and reference, and we regard the publication of the Emancipation Proclamation, and the President's Inaugurals, and their wide diffusion throughout the people, as a matter of great importance, for they abound in sentiments which ought to become watchwords among us, and they appear to us likely to be cherished by succeeding generations as the farewell address is by us. The oration is, we suppose, a necessary diluent in all American ceremonies, as the nitrogen is in our atmosphere. The portrait seems to us to be, so far as likeness is concerned, one of the best we have seen, especially from its giving something of that remarkable expression of the eyes which was so characteristic a feature in the face of our martyred President. We hope this little publication will be widely diffused, as we feel sure that few, even in the party of his assassins, can read his sentiments without being, at least for the moment, better for them.

A Comparison of some of the Meteorological Phenomena of the SPRING, of 1865, *with that of* 1864, *and of the same season for* FOURTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 10½′ W. from Greenwich. By J. A. KIRKPATRICK, A. M.

	Spring, 1865.	Spring, 1864.	Spring, for 14 years.
Thermometer—Highest—degree, . .	84·00°	86·00°	90·00°
" date, . . .	May 17.	May 10, 31.	May 7 60,23 63
Warmest day—Mean,	75·50	78·17	79·83
" " date,	May 17th.	May 9th.	May 23d, '60
Lowest—degree, . .	24·00	20·00	4·00
" date, . . .	Mar. 11th.	Mar. 22d.	Mar. 10, '56.
Coldest day—Mean, .	31·67	27·33	11·50
" " date, .	Mar. 11th.	Mar. 22d.	Mar. 10, '56.
Mean daily oscillation,	14·04	15·19	16·05
" " range, .	6·44	5·14	5·98
Means at 7 A. M., . .	51·05	47·26	46·80
" 2 P. M., . .	61·11	58·09	58·09
" 9 P. M., . .	54·01	50·88	50·56
" for the Spring,	55·39	52·05	51·82
Barometer—Highest—Inches, . . .	30·265 in.	30·131 in.	30·522 in.
" date, . . .	Apr. 9th.	Mar. 3d.	Mar. 3d, '52.
Greatest mean daily press.,	30·208	30·090	30·458
" date, . . .	Apr. 9th.	Mar. 3d.	Apr. 3d, '54
Lowest—Inches, . . .	29·185	29·184	28·884
" date, . . .	Mar. 22d.	Mar. 30th.	Apr. 21, '52
Least mean daily press., .	29·241	29·246	28·959
" date, . . .	Mar. 22d.	Mar. 30th.	Apr. 21, '52
Mean daily range, . . .	0·162	0·135	0·161
Means at 7 A. M., . . .	29·821	29·705	29·822
" 2 P. M., . . .	29·776	29·661	29·777
" 9 P. M., . . .	29·818	29·706	29·809
" for the Spring, .	29·805	29·691	29·803
Force of Vapor—Greatest—Inches, .	0·689 in.	0·714 in.	0·771 in.
" date, . .	Apr. 29th.	May 24th.	May 14, '54.
Least—Inches, . .	·076	·064	·023
" date, . .	Mar. 6th.	Mar. 20th.	Mar. 5, 1858.
Means at 7 A. M., . .	·284	·263	·252
" 2 P. M., . .	·306	·278	·267
" 9 P. M., . .	·303	·286	·271
" for the Spring,	·298	·276	·263
Relative Humidity—Greatest—per ct.,	96·0 per ct.	97·0 per ct.	100 per ct.
" date, .	Mar. 9, 31.	May 26th.	often.
Least—per ct., .	23·0	18·0	13·0
" date, . .	Apr. 24th.	Mar. 9, Ap. 7	Ap. 13, 1852.
Means at 7 A. M.,	70·4	71·9	72·0
" 2 P. M.,	53·8	52·4	52·0
" 9 P. M.,	67·8	69·1	67·9
"for the Spring,	64·0	64·5	64·0
Clouds—Number of clear days,* . .	21	21	28·2
" cloudy days, . .	71	71	63·8
Means of sky cov'd at 7 A.M., .	66·7 per ct.	62·2 per ct.	60·8 per ct.
" " " 2 P.M., .	68·4	68·6	63·0
" " " 9 P.M., .	54·5	59·2	48·9
" " for the Spring, .	63·2	63·3	57·6
Rain—Amount, ...	15·396 in.	18·763 in.	13·002 in.
No. days on which Rain fell, . . .	37.	36.	36·6
Prevailing Winds—Times in 1000,	s62°34′w·172	N52°39′w·096	N70°39′w·181

* Sky one-third or less covered at the hours of observation.

A Comparison of some of the Meteorological Phenomena of MAY, 1865, *with those of* MAY, 1864, *and of the same month for* FOURTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 10½′ W. from Greenwich. By J. A. KIRKPATRICK, A. M.

	May, 1865.	May, 1864.	May, for 14 years.
Thermometer—Highest—degree, . .	84·0°	86·00°	90·00°
" date, . . .	17th.	10th, 31st.	7th 60, 23d 63
Warmest day—mean,	75·50	78·17	79·83
" " date,	17th.	9th.	23d, 1863.
Lowest—degree, . .	46·00	41·00	35·00
" date, . . .	1st, 2d, 12th.	3d.	7th, 1854.
Coldest day—mean, .	50·50	49·67	40·00
" " date, .	1st.	3d.	3d, 1861.
Mean daily oscillation,	13·81	16·61	17·00
" " range, .	6·60	5·03	5·58
Means at 7 A. M., . .	59·87	62·53	58·66
" 2 P. M., . .	68·91	73·35	69·85
" 9 P. M., . .	61·39	65·15	61·57
" for the month,	63·39	67·01	63·36
Barometer—Highest—inches, . . .	30·147 in.	30·000 in.	30·338 in.
" date, ...	15th.	5th.	4th, 1852.
Greatest mean daily press.,	30·120	29·978	30·273
" date, ...	15th.	5th.	5th, 1852.
Lowest—inches, . . .	29·405	29·379	29·096
" date, ...	22d.	10th.	27th, 1861.
Least mean daily press., .	29·447	29·437	29·243
" date, . . .	22d.	0·108	27th, 1861.
Mean daily range, . . .	0·126	10th.	0·120
Means at 7 A. M., . . .	29·742	29·663	29·808
" 2 P. M., . . .	29·708	29·627	29·770
" 9 P. M., . . .	29·740	29·665	29·795
" for the month, .	29·730	29·652	29·792
Force of Vapor—Greatest—inches, .	0·683 in.	0·714 in.	0·771 in.
" date, . .	20th.	24th.	14th, 1854.
Least—inches, . .	·143	·202	·069
" date, . . .	3d.	3d.	2d, 1861.
Means at 7 A. M., .	·380	·423	·359
" 2 P. M., .	·389	·452	·376
" 9 P. M., .	·402	·461	·382
" for the month,	·390	·445	·372
Relative Humidity—Greatest—per ct.,	95.0 per ct.	97·0 per ct.	100 per ct.
" date, .	8th.	26th.	often.
Least—per ct., .	24·0	32·0	16·0
" date, . .	3d.	28th.	5th, 1855.
Means at 7 A. M.,	71·7	73.2	71·4
" 2 P. M.,	54·9	54·5	51·5
" 9 P. M.,	72·0	73·6	68·7
" for the month,	66·2	67·1	63·9
Clouds—Number of clear days,* . .	5	7	10
" cloudy days, . .	26	24	21
Means of sky cov'd at 7 A. M.,	76·1 per ct.	62·9 per ct.	59·5 per ct.
" " " 2 P. M.,	69·4	69·0	60 9
" " " 9 P. M.,	54·5	58·4	47·0
" " for the month,	66·6	63·4	55·8
Rain—Amount, ...	7·692 in.	9·042 in.	4·829 in.
No. of days on which rain fell, . .	13	12	12·7
Prevailing Winds—Times in 1000,	s74° 17′ w·190	s22°23′w·105	s 78°26′w·109

*5ky, one-third or less covered at the hours of observation.

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